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(6) SPECIAL REPORT NO. 2
AN EVALUATION OF FUEL CELL
SYSTEMS FOR MILITARY VEHICLE
PROPULSION AND PORTABLE
ELECTRIC POWER GENERATION.

PART 2.

February 1, 1965

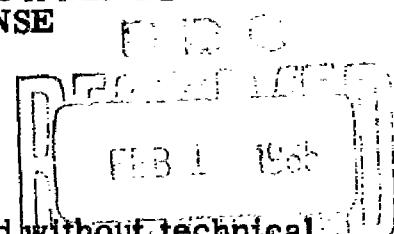
By

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Part 2 of 2 Parts

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UNITED STATES ARMY MATERIEL COMMAND
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A P P E N D I X A

POWER DENSITIES AND FUEL CONSUMPTION OF GASOLINE AND DIESEL ENGINES

In order to give a consistent basis of comparison, we have chosen to relate fuel cell systems to typical military gasoline and diesel engines. The engines chosen are the 150 hp gasoline engine and 330 hp diesel engine systems used by Cather¹ and by us² in earlier comparisons. Basic data are given in Table I and Figure 2 of this report.

Fuel utilization efficiencies for the reference engines over a range of engine power outputs and engine speeds are not available from the Cather report,¹ which gives only the brake specific fuel consumptions (bsfc) at optimum conditions. For purposes of comparison, published data for gasoline and diesel engines similar in size to the reference engines were used to obtain the curves shown in Figure 2. Average fuel consumption figures were estimated from these curves. Small adjustments were applied to bring the optimum efficiencies from the curves in line with the values calculated from Cather's data for the reference engines.

For the engines considered, there is a single condition giving maximum power output. In Table A-1 the best and poorest brake specific fuel consumptions (bsfc) within the range of available data are shown as a function of per cent of maximum power output (load factor).

These values were taken from the references listed. Fuel utilization efficiencies calculated from the bsfc values are also shown. Fuel utilization efficiencies versus per cent of maximum engine power output are plotted in Figure 2. Table A-1 also contains values for energy produced per pound and gallon of fuel as a function of engine and engine plus transmission power densities. These numbers were used in constructing the engine curves which are compared with fuel cell systems in Figures 3 and 4.

Power density data for several gasoline and diesel engines having power ratings approximating those of the reference engines (Table I) are

TABLE A-1

**POWER DENSITIES AND FUEL CONSUMPTIONS
OF GASOLINE AND DIESEL ENGINES**

Per Cent of hp	Gasoline Engine						Diesel Engine					
	Power Density ^a Engine + Transmission, hp/cu ft		Fuel Consumption Engine + Transmission bsfc, lb/hr- cu ft		Power Density ^a Engine + Transmission, bsfc, lb/hr- cu ft		Power Density ^a Engine + Transmission, bsfc, lb/hr- cu ft		Fuel Consumption Engine + Transmission, bsfc, lb/hr- cu ft		Engine + Transmission a. ho-hr/EI	
	Engine, hp/cu ft	bsfc lb/hr- cu ft	Engine Fuel Efficiency, a. deg	bsfc lb/hr- cu ft	Engine Fuel Efficiency, a. deg	bsfc lb/hr- cu ft	Engine Fuel Efficiency, a. deg	bsfc lb/hr- cu ft	Engine Fuel Efficiency, a. deg	bsfc lb/hr- cu ft	Engine Fuel Efficiency, a. deg	bsfc ho-hr/1b
10	0.8	0.43	> 1.3	> 11.1	> 0.60	1.05	0.44	> 31.1	> 11.0	> 1.60	> 11.0	> 1.60
20	1.6	0.85	> 0.75	> 19.2	> 0.64	2.1	0.87	> 34.2	> 12.0	> 1.75	> 12.0	> 1.75
30	2.4	1.28	1.40-0.635	10.7-0.635	0.56-1.23	3.15	1.31	0.485-0.37	28.2-37.0	9.6-13.0	1.45-1.90	1.45-1.90
40	3.2	1.71	1.07-0.58	13.5-24.8	0.73-1.35	4.2	1.75	0.485-0.37	20.1-26.0	10.6-13.4	1.55-1.96	1.55-1.96
50	4.0	2.14	0.95-0.555	15.2-26.0	5.1-8.7	6.25	2.17	0.455-0.36	31.8-38.0	11.2-13.3	1.64-1.95	1.64-1.95
60	4.8	2.56	0.90-0.555	16.0-26.0	5.4-8.7	6.3	2.62	0.433-0.36	31.4-37.5	11.6-13.1	1.70-1.92	1.70-1.92
70	5.6	2.99	0.86-0.59	16.8-25.7	5.6-8.7	7.35	3.06	0.410-0.365	34.2-36.5	11.9-12.9	1.74-1.86	1.74-1.86
80	6.4	3.42	0.82-0.57	17.6-25.3	5.8-8.5	8.4	3.50	0.400-0.375	34.2-35.5	12.0-12.5	1.76-1.82	1.76-1.82
90	7.2	3.84	0.79-0.595	18.2-24.2	6.1-8.0	9.45	3.93	0.400-0.385	34.2-35.5	12.0-12.5	1.76-1.82	1.76-1.82
100	8.0	4.27		22.2	7.4	10.5	4.37	0.400-0.385	34.2-35.5	12.0-12.5	1.76-1.82	1.76-1.82

a. Power densities, engine efficiencies, and engine + transmission fuel consumption values, are for the engines and engine-transmission systems in Table I.

b. Gasoline fuel consumption data were taken from Reference 49, Figure 113, page 220. They are for a 1946 Ford V-8 engine installed with fan, generator, muffler, tailpipe, and automatic spark advance control. The data cover the operating range from 500-2500 rpm and from about 8% to 100% of maximum power. The figures were found to correspond approximately to data points from later model engines.

c. Diesel fuel consumption data were taken from Reference 50, Figure 20. They are for a two-stroke, 4-cylinder, 200 hp diesel engine. The data cover the range 700-1600 rpm and about 25% to maximum hp.

d. It was assumed that fuel consumption characteristics of the reference engines (Table I) would correspond closely to those of the engines described in footnotes b and c. Therefore, for the gasoline engine, fuel efficiencies were calculated assuming that the minimum basic (0.555) corresponded to the optimum efficiency calculated for the reference engine (bsfc, 0.55). With the diesel engine, the minimum basic (0.36) was assumed to correspond to 38% optimum efficiency for the reference diesel engine (bsfc, 0.38). These engine efficiencies are based on the net heating values of the fuels.

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given in Table A-2. The power densities of the gasoline industrial engines and highly developed military diesel engines approximate those of the reference engines. The power densities of typical industrial diesel engines are only one half to two thirds those of highly developed military diesel engines.

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TABLE A-2
**POWER DENSITIES OF GASOLINE
AND DIESEL ENGINES**

Engine	Power Rating Max. bhp ^a	Engine Weight, lb	Engine Volume, ^c cu ft	Power Density		References
				bhp/lb	bhp/cu ft	
Gasoline Industrial Engines						
Chevrolet 327	158	622	23.5	0.25	6.7	51
Chrysler 318	150	550	15.3	0.27	9.8	51
Ford 292	153	553	18.0	0.28	8.5	51
GMC 351	155	-	26.8	-	5.8	51
Studebaker 289	156	634	16.2	0.25	9.6	51
Average	154	590	20.0	0.26	7.7	
Reference Engine (Table I)	150	750	18.8	0.20	8.0	1
Diesel Industrial Engines						
Cummins 855	325	2750	55.0	0.12	5.9	51
Cummins 950	365	3020	62.1	0.12	5.9	51
GMC 851	390	5620	177.4	0.07	2.2	51
International						
Harvester 817	362	3540	77.7	0.10	4.7	51
Average	360	3732	93.0	0.10	4.7	
Diesel Military Engines						
Lycoming S and H	(100) ^b	600	14.4	0.20	(6.9) ^d	52
Caterpillar LDS-750	425	2000	42.5	0.21	10.0	53
Reference Engine (Table I)	330	1600	31.4	0.21	10.5	1

a. Maximum brake horsepower with standard accessories.

b. Estimated from gross rating (without accessories), 120 bhp.

c. "Box volume." Product of maximum dimensions.

d. Calculated from estimated maximum brake horsepower.

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A P P E N D I X B

POWER DENSITIES AND FUEL CONSUMPTIONS OF PRESENT FUEL CELLS

Data representative of the best reported fuel cell current densities and efficiencies are given in Table B-1. The hydrogen-oxygen data are for prototype units for which more than 500,000 hours of test data have been obtained. The hydrazine-oxygen fuel cell data are also from a prototype unit, used in this case to power a golf cart. This unit has not had anywhere near the amount of development that has been expended on the hydrogen-oxygen cells. The other data are from laboratory experiments. These cells do not have proven "operating life" at the present time.

In order to provide a consistent basis for comparison of the different fuel cell systems, it is assumed that the cell thickness in each case is one-fourth inch and that there are 48 square feet of anode surface per cubic foot of fuel cell. In the calculations, the volumes of accessory equipment are disregarded. These volumes may well reduce the power densities of the fuel cell systems to less than one half the values given.

The electric motor volumes were calculated on the basis of 10 hp per cubic foot. This value is essentially the same as was used by Cather¹ in a more general comparison of fuel cell-transmission systems. The rated motor size was taken arbitrarily as 70% of the maximum output obtainable from the fuel cell. In the case of the hydrogen-oxygen fuel cell system, the motor size was selected to correspond to 100 amperes per square foot current density which is the maximum for continuous operation of this cell. Double this current density is allowable for short periods.

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TABLE B-1

FUEL CELL PERFORMANCE DATA

Fuel Cells and Constants Used in Calculations	Cell Potential, volts	Current Density, amp/sq ft	Power Density ^a			Thermal Efficiency, ^c Fuel Cell Only, %	Power Produced per Unit of Fuel		
			Fuel Cell Only w/sq ft	Fuel Cell & d-c Motor, ^b hp/cu ft	Fuel Cell Only hp/cu ft		Fuel Cell Only, hp-hr/lb	Fuel Cell + d-c Motor ^d hp-hr/lb	Fuel Cell + d-c Motor ^d hp-hr/gal
Hydrogen-Oxygen (Union Carbide, Ref. 54)	1.01	25	25	1.65	0.8	68	16.3	11.4	6.75
$E^o = 1.229$ volts	0.95	50	48	3.05	1.5	64	15.4	10.8	6.4
$\Delta F_c/\Delta H_c = 0.829$	0.93	75	70	4.5	2.2	63	15.0	10.5	6.2
60°C, Atm. Press., Aq. KOH Electrolyte	0.90	100	90	5.8	2.85	61	14.5	10.2	6.05
0.88	125	110	7.1	3.45		59.5	14.2	9.95	5.9
0.87	150	131	8.45	4.1		58.5	14.1	9.85	5.85
Intermittent Operation only above 100 amp/sq ft Current Density	0.86	175	150	9.65	4.7	58	13.9	9.75	5.8
	0.85	200	170	11.0	5.35	57.5	13.7	9.6	5.7
Hydrazine-Oxygen (Allis-Chalmers, Ref. 55) ^e	1.01	50	50	3.2	1.05	62.5	2.92	1.41	11.6
$E^o = 1.56$ volts	0.94	100	94	6.05	2.0	58	1.82	1.28	10.5
$\Delta F_c/\Delta H_c = 0.963$	0.81	200	162	10.4	3.45	50	1.62	1.13	9.25
70°C, Atm. Press., 0.9M Hydrazine in 5.5M KOH Electrolyte	0.70	300	210	13.5	4.5	43	1.40	0.98	8.05
0.585	400	234	15.1	5.0		36	1.17	0.82	6.7
0.47	500	235	15.2	5.0		29	0.94	0.66	5.4
0.35	600	210	13.5	-		21.5	0.70	0.49	4.0
	0.22	700	154	9.9	-	13.5	0.44	0.31	2.55
Methanol-Oxygen (Esso, Ref. 56)									
$E^o = 1.215$ volts	0.65	9.3	6.1	0.39	0.24	52.5	2.00	1.40	9.3
$\Delta F_c/\Delta H_c = 0.984$	0.58	19	10.8	0.71	0.44	47	1.78	1.25	8.3
82°C, Atm. Press., 1.8M Methanol in 30% H_2SO_4 Electrolyte	0.44	47	20.7	1.33	0.83	35.5	1.35	0.94	6.25
0.37	57	24.8	1.60	1.00		30	1.14	0.80	5.3
	0.28	93	26.0	1.68	1.05	22.5	0.86	0.60	4.0
Propane Oxygen (G.E., Ref. 8, Fig. 16)	0.68	9.3	6.3	0.41	0.25	59.5	5.1	3.55	15.3
$E^o = 1.091$ volts	0.61	19	11.6	0.75	0.45	53.5	4.5	3.2	13.7
$\Delta F_c/\Delta H_c = 0.955$	0.52	37	19.2	1.28	0.75	45.5	3.9	2.7	11.7
200°C, 96% H_3PO_4 , Atm. Press.	0.46	56	25.8	1.66	1.00	40.5	3.4	2.4	10.4
0.40	74	29.6	1.91	1.15		35	3.0	2.1	9.0
0.35	93	32.6	2.10	1.27		30.5	2.6	1.8	7.9
0.31	112	34.7	2.24	1.35		27	2.3	1.6	7.0
0.27	130	35.1	2.26	1.36		23.5	2.0	1.4	6.1
0.23	149	34.3	2.21	-		20	1.7	1.2	5.2
	0.20	167	33.4	2.16	-	17.5	1.5	1.05	4.5
n-Octane-Oxygen (O.E., Ref. 8, Fig. 17)	0.59	9.3	5.5	0.35	0.22	51.5	4.2	2.95	17.2
$E^o = 1.100$ volts	0.53	19	10.1	0.65	0.41	46.5	3.8	2.65	15.5
$\Delta F_c/\Delta H_c = 0.962$	0.45	37	16.7	1.07	0.67	39.5	3.2	2.25	13.1
200°C, 96% H_3PO_4 , Atm. Press.	0.38	56	21.3	1.37	0.86	33	2.7	1.9	11.0
0.34	74	25.2	1.62	1.01		29.5	2.4	1.7	9.9
0.29	93	27.0	1.74	1.09		25.5	2.1	1.45	8.5
0.24	112	26.9	1.75	1.09		21	1.7	1.2	7.0
0.21	130	27.3	1.76	1.10		18.5	1.5	1.05	6.1
	0.17	149	25.3	1.60	-	15	1.2	0.85	5.0

a. Fuel cell power density based on standard design using cells 1/4-inch thick having an anode area of 48 square feet per cubic foot of cell.

b. The d-c motor size for continuous operation is taken as 70% of the maximum fuel cell power output. Motor volume was calculated assuming 10 hp per cubic foot.

c. Thermal efficiency = $\frac{\Delta F_c}{\Delta H_c} \cdot \frac{E}{E^o}$
where ΔF_c is the free energy of combustion, ΔH_c is the heat of combustion under the same conditions, E is the actual potential across the cell terminals, and E^o is the theoretical reversible potential for complete combustion of the fuel. The gross heat of combustion of the fuel was used in these calculations. See Table C-1.

d. The combined efficiency of the d-c motor, controls, and power train is assumed to be 70%.

e. This hydrazine-oxygen fuel cell is reported to give only about 80% of the current expected from complete oxidation of the fuel. This results from direct chemical oxidation of part of the fuel. This low "current efficiency" can probably be corrected by improved cell design and is ignored in the calculations and curves.

A P P E N D I X C

HEATS OF COMBUSTION OF SOME FUELS

Gross heats of combustion used in calculations for Table B-1 and net heats of combustion used in comparative thermal efficiency calculations in the body of this report are tabulated in Table C-1.

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TABLE C-1
HEATS OF COMBUSTION OF SOME FUELS

Fuel	Net Heat of Combustion (25°C, H ₂ O Vapor)		Gross Heat of Combustion (25°C, H ₂ O Liquid)	
	Btu/lb	Btu/gal	Btu/lb	Btu/gal
Hydrogen	51,570	30,600 ^a	60,960	36,100 ^a
Methanol (aq.) ^b	8,475	56,100	9,660	64,000
Ammonia (aq.) ^b	7,120	36,400	8,790	44,900
Hydrazine (aq.) ^b	7,120	58,500	8,250	67,700
Methane	21,500	75,800 ^c	23,860	84,100 ^c
Propane	19,930	82,100	21,650	89,200
n-Octane	19,100	111,000	20,750	121,000
Motor Gasoline (30% Aromatics)	18,500	115,000	20,000	124,000
Diesel Fuel	17,500	120,000	19,000	130,000

a. -257°C.

b. Heat of combustion in aqueous solution as oxidized in fuel cells.

c. -160°C.

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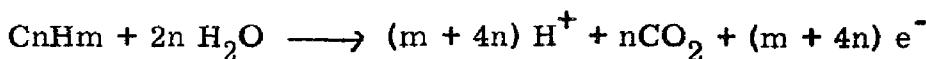
APPENDIX D

DIRECT n-NONANE - AIR FUEL CELL MATERIAL BALANCE CALCULATIONS

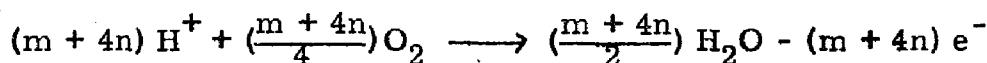
Flow rates and system stream compositions are required if water balance and fuel recovery from exhaust streams are to be analyzed. The model used as the basis for the calculations and discussion which follows and definitions of the symbols used are shown in Figure D-1.

The generalized half cell reactions for any direct hydrocarbon fuel cell using acid electrolyte are:

Anode Reaction:



Cathode Reaction:



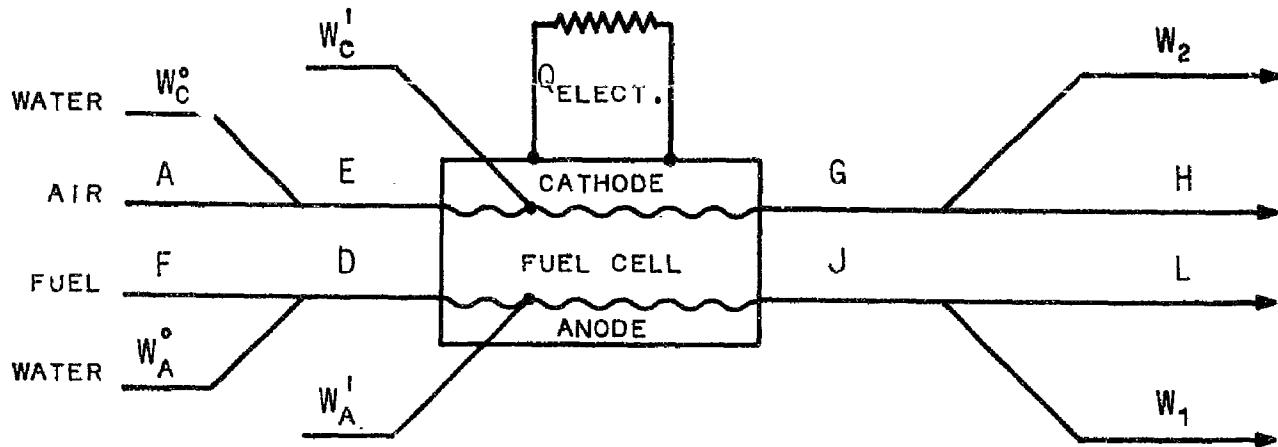
If a = moles of hydrocarbon reacted in the fuel cell according to the half cell reactions, then the reaction stoichiometry gives the following relationships:

Anode Streams:*

Component	Anode Feed (D) Moles	Net Reaction, Moles	For Water Balance, Moles	Anode Exhaust (J) Moles
Fuel	F	-a		F-a
H_2O	W_A°	$-2na$	W_A'	$W_A^\circ - 2na$
CO_2	-	+na		+na
Total	$F + W_A^\circ$	$-(n+1)a$		$F + W_A^\circ - (n+1)a$

* The capital letters which appear in the headings of the tables in this section refer to fuel cell reactant and product streams shown in Figure D-1.

FIGURE D-1

DIRECT HYDROCARBON FUEL CELL MODEL FOR
WATER BALANCE AND FUEL RECYCLE

W_C^o = WATER PRESENT IN CATHODE FEED.

W_C^i = WATER TO OR FROM ELECTROLYTE TO CATHODE GAS STREAM:

$$1. \quad W_C = W_C^o + W_C^i$$

ANODE WATER SYMBOLS CORRESPOND TO THOSE FOR CATHODE:

$$2. \quad W_A = W_A^o + W_A^i$$

W_1 = WATER RECOVERED FOR RECYCLE FROM ANODE EXHAUST "J".

W_2 = WATER RECOVERED FOR RECYCLE FROM CATHODE EXHAUST "G".

P = ANODE AND CATHODE STREAM PRESSURE.

ρ_{H_2O} = VAPOR PRESSURE OF WATER FROM ELECTROLYTE.

X_F = MOLE FRACTION OF FUEL IN THE ANODE EXHAUST GAS "J".

X_{H_2O} = MOLE FRACTION OF WATER IN THE ANODE EXHAUST GAS "J".

Y = FRACTIONAL APPROACH TO WATER EQUILIBRIUM WITH ELECTROLYTE:

$$3. \quad X_{H_2O} = Y \cdot \frac{P_{H_2O}}{P} \quad (\text{ANODE EXHAUST})$$

$X_{O_2}^i$ = MOLE FRACTION OF OXYGEN IN CATHODE EXHAUST GAS "G".

$X_{H_2O}^i$ = MOLE FRACTION OF WATER IN THE CATHODE EXHAUST GAS "G".

Z = FRACTIONAL APPROACH TO WATER EQUILIBRIUM WITH ELECTROLYTE:

$$4. \quad X_{H_2O}^i = Z \cdot \frac{P_{H_2O}}{P} \quad (\text{CATHODE EXHAUST})$$

Cathode Streams:*

Component	Cathode Feed (D) Moles	Net Reaction, Moles	For Water Balance, Moles	Cathode Exhaust (G) Moles
O ₂	0.21A	- $(\frac{m+4n}{4})a$		$0.21A - (\frac{m+4n}{2})a$
N ₂	0.79A			0.79A
H ₂ O	W _C °	$+(\frac{m+4n}{2})a$	W _C '	$W_C + (\frac{m+4n}{2})a$
Total	A+W _C °	$+(\frac{m+4n}{4})a$		$A + W_C (\frac{m+4n}{2})a$

$$F[(1 - X_F)(1 - X_{H_2O}) - X_F X_{H_2O}]$$

$$a = \frac{X_F[2n - (n + 1)X_{H_2O}] + (1 - X_{H_2O})[1 - (n + 1)X_F]}{X_F}$$

$$W_A = \frac{F(1 - X_F) - a[1 - (n + 1)X_F]}{X_F}$$

$$W_C = \frac{X_{H_2O}[A + (\frac{m+4n}{4})X_{H_2O}] - (\frac{m+4n}{2})}{1 - X_{H_2O}}$$

For nonane hydrocarbons these relations simplify as follows:

Anode Streams:

Component	Anode Feed (E) Moles	Net Reaction, Moles	For Water Balance, Moles	Anode Exhaust (J) Moles
n-Nonane	F	-a		F-a
H ₂ O	W _A °	-18a	W _A '	$W_A - 18a$
CO ₂	-	+9a		+9a
Total	F+W _A °	-10a		$F + W_A - 10a$

* The capital letters which appear in the headings of the tables in this section refer to fuel cell reactant and product streams shown in Figure D-1.

Cathode Streams:

Component	Cathode Feed \textcircled{E} Moles	Net Reaction, Moles	For Water Balance, Moles	Cathode Exhaust \textcircled{G} Moles
O_2	0.21A	-14a		0.21A - 14a
N_2	0.79A			0.79A
H_2O	W_C°	+28a	W_C'	$W_C + 28a$
Total	$A + W_C^{\circ}$	+14a		$A + W_C + 14a$

$$a = \frac{F[(1 - X_F)(1 - X_{\text{H}_2\text{O}}) - X_F X_{\text{H}_2\text{O}}]}{X_F(18 - 10 X_{\text{H}_2\text{O}}) + (1 - X_{\text{H}_2\text{O}})(1 - 10 X_F)}$$

$$W_A = \frac{F(1 - X_F) - a(1 - 10 X_F)}{X_F}$$

$$W_C = \frac{X_{\text{H}_2\text{O}}(A + 14a) - 28a}{1 - X_{\text{H}_2\text{O}}}$$

The assumptions and results from some material balance calculations for a direct nonane-air fuel cell using 94 weight per cent phosphoric acid electrolyte at 300° F and 1 atmosphere pressure are shown in Table D-1. In these calculations, it is assumed that nonane reacts only to give CO_2 and H_2O and that no conversion to lower molecular weight hydrocarbons occurs. In practice, it is probable that some such reactions will occur. The effect of this on hydrocarbon recycle losses will be discussed later.

In Case A of Table D-1, nonane is assumed to react so rapidly that its concentration in the anode exhaust can be reduced to 2 mole per cent. Calculations are based on one mole of nonane. Sufficient air is supplied so that the cathode air stream retains 5 mole per cent of unreacted oxygen. It is also assumed that the partial pressures of water from the

TABLE D-1

MATERIAL BALANCES AND STREAM COMPOSITIONS FOR A
DIRECT NONANE-AIR FUEL CELL, 94 WT. % PHOSPHORIC ACID
ELECTROLYTE AT 300°F AND 1 ATM. PRESSURE

		A	A-1		
<u>Specified Values:</u>					
Electrolyte Partial Pressure	p _{H₂O} , mm	200	200		
Total Pressure	P, mm	760	760		
Approach to Water Balance, Cathode Exhaust	Z	1	1		
Approach to Water Balance, Anode Exhaust	Y	1	1		
Fuel Rate	F, moles/hr	1	0.452		
Mole Fraction of Fuel in Anode Exhaust	X _F	0.02	0.02		
Mole Fraction of Water in Anode Exhaust	X _{H₂O}	0.263	0.263		
Mole Fraction of Oxygen in Cathode Exhaust	X _{O₂}	0.05	0.05		
Mole Fraction of Water in Cathode Exhaust	X' _{H₂O}	0.263	0.263		
<u>Material Balance:</u>					
Fuel Oxidized, moles/hr	a	0.799	0.361		
<u>Anode Feed Stream (D):</u>		Moles/Hr	Mole %	Moles/Hr	g/Hr
n-Nonane	W _A	1.00		0.45	58.0
Water		0		0	0
	Total	1.00		0.45	58.0
Water Added to Anode Stream	W _A	17.03		7.69	138.6
<u>Anode Exhaust Stream (J):</u>					
n-Nonane	W _{A'}	0.20	2.0	0.09	11.7
Water		2.64	26.3	1.19	21.5
Carbon Dioxide		7.19	71.7	3.25	143.0
	Total	10.03	100.0	4.53	176.2
<u>Cathode Feed Stream (E):</u>					
Oxygen	W _C	15.41	21.0	6.96	222.8
Nitrogen		57.97	79.0	26.19	733.7
Water		0.00			
	Total	78.38	100.0	33.15	956.5
Water Added to Cathode Stream	W _C	-0.17		0.08	-1.4
<u>Cathode Exhaust Stream (G):</u>					
Oxygen	W _{C'}	4.22	5.00	1.97	62.9
Nitrogen		57.92	68.68	26.16	733.7
Water		22.21	26.32	10.03	180.8
	Total	84.35	100.00	38.16	977.4

anode and cathode streams are equal to each other and to the partial pressure of water from the fuel cell electrolyte. In this preliminary calculation, we have also assumed that no water was added either to the hydrocarbon feed, to the fuel cell, or to the cathode air stream. As a result, the anode stream has had to draw 17.03 moles of water from the electrolyte to meet exhaust stream specifications, while the water formed at the cathode was 0.167 mole in excess of that required for the cathode exhaust. This excess is added to the electrolyte. Therefore, the fuel cell has a net requirement of 16.86 moles of water per mole of nonane in the fuel. This water could be added to the anode stream which then would greatly dilute the electrolyte where the anode feed enters the fuel cell, or it could be divided in some way between the air and fuel stream in an effort to minimize undesirable concentration effects. If this water is added as liquid, either through the electrolyte or in some other way, its heat of vaporization would provide about one fourth of the cooling required by the fuel cell at maximum power.

An attempt to relate Case A which was discussed above to a particular fuel cell situation is made in Case A-1 of Table D-1. This is discussed in Section VII-C of the report.

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A P P E N D I X E

COMPUTER CALCULATIONS MATHEMATICAL TREATMENTS

1. Calculation of Equilibrium Constants

The equilibrium constants for the reforming reaction, K_R , the shift reaction, K_S , and the Boudouard reaction, K_C , can be represented over small temperature intervals with very high accuracy by means of the two-parameter Arrhenius equation

$$(1.1) \quad K = Ae^{B/RT},$$

where A and B are experimental constants, R is the universal gas constant, and T the absolute temperature. Values of the equilibrium constants, K_R , K_S , and K_C , were calculated from literature values⁵⁷ of the equilibrium constants of formation in the range of 200°F to 2200°F obtained at 100°K intervals. The constants were then calculated for any temperature by linear interpolation of the natural logarithm of K, lnK, against the reciprocal absolute temperature, $\frac{1}{T}$, in the proper 100°F interval.

2. Calculation of Reformer Product Composition

When feed consisting of carbon, hydrogen, and oxygen compounds in any fashion are fed to a reformer, the products are water, carbon dioxide, methane, carbon monoxide, and molecular hydrogen. Any inert gas feed, such as nitrogen, is recovered unreacted.

In the mathematical development below, parentheses around a chemical formula will indicate number of pound-moles of a product. The symbol (—) is used to represent pound-moles or pound-atoms in the feed streams. If the reformer feed can be represented by

$$(\bar{O}), (\bar{H}), (\bar{C}), \text{ and } (\overline{\text{Inerts}}),$$

then the following mass balance equations must be satisfied for the reformer products:

$$(2.1) \quad \left\{ \begin{array}{l} (\text{O}) = (\text{H}_2\text{O}) + 2(\text{CO}_2) + (\text{CO}) \\ (\text{H}) = 2(\text{H}_2\text{O}) + 4(\text{CH}_4) + 2(\text{H}_2) \\ (\text{C}) = (\text{CO}_2) + (\text{CO}) + (\text{CH}_4) \\ (\text{Inerts}) = (\text{Inerts}) \end{array} \right.$$

The product composition consisting of five unknowns (the molecular species other than inerts) can thus be reduced to two unknowns by the equations in (2.1). Thus if we arbitrarily choose the water and carbon dioxide concentrations to be unknowns,

$$(2.2) \quad \left\{ \begin{array}{l} (\text{CO}_2) = X \\ (\text{H}_2\text{O}) = Y \end{array} \right.$$

we can express the other concentrations in terms of X and Y and the known feed composition:

$$(2.3) \quad \left\{ \begin{array}{l} (\text{CH}_4) = (\text{C}) - (\text{O}) + X + Y \\ (\text{CO}) = (\text{O}) - 2X - Y \\ (\text{H}_2) = 1/2(\text{H}) - 2(\text{C}) + 2(\text{O}) - 2X - 3Y \end{array} \right.$$

When the equations (2.2) and (2.3) are combined with the expressions for the reforming and shift equilibria, two polynomials in two unknowns are obtained

$$(2.4) \quad \left\{ \begin{array}{l} K_R = \frac{(\text{CO})(\text{H}_2)^3 P^2}{(\text{CH}_4)(\text{H}_2\text{O})(\text{Total})^2}, \text{ and} \\ K_S = \frac{(\text{CO}_2)(\text{H}_2)}{(\text{CO})(\text{H}_2\text{O})} \end{array} \right.$$

where P is pressure expressed in atmospheres and $(\text{Total}) = (\text{CO}) + (\text{H}_2) + (\text{CH}_4) + (\text{H}_2\text{O}) + (\text{CO}_2) + (\text{Inerts})$. This quantity has to be introduced as a normalizing factor since the components are introduced in terms of moles rather than partial pressures. The polynomials in two unknowns may be solved by one of a number of numerical methods. In our calculations the Newton-Raphson method⁵⁸ was used.

3. Determination of Water Needed to Inhibit Carbon Deposition

A reversible reaction which needs to be considered in the reforming process is the following:



The equilibrium constant, K_C , was calculated as a function of temperature as described in Section 1. The mass action ratio, "RT," for this reaction is given in terms of moles by:

$$(3.2) \quad "RT" = \frac{(\text{CO}_2) \text{ (Total)}}{(\text{CO})^2 P}$$

If "RT" is greater than K_C , carbon will not be formed. If "RT" is smaller than K_C , carbon will be deposited. The addition of a sufficient amount of water will then prevent carbon formation by reducing the carbon monoxide concentration and increasing the carbon dioxide concentration. If Z is defined as minimum amount of water necessary to prevent carbon formation, then Z must be such that the following equation is satisfied:

$$(3.3) \quad K_C = \frac{(\text{CO}_2) \text{ (Total)}}{(\text{CO})^2 P}$$

The method of solution follows that of Section 2 except that the Newton-Raphson method must now be applied to three polynomials in three unknowns:

$$(3.4) \quad \left\{ \begin{array}{l} K_R = \frac{(\text{CO})(\text{H}_2)^3 P^2}{(\text{CH}_4)(\text{H}_2\text{O}) \text{ (Total)}^2} \\ K_S = \frac{(\text{CO}_2)(\text{H}_2)}{(\text{CO})(\text{H}_2\text{O})} \\ K_C = \frac{(\text{CO}_2) \text{ (Total)}}{(\text{CO})^2 P} \end{array} \right.$$

where the components are given in terms of unknowns X, Y, and Z by:

$$(3.5) \quad \begin{aligned} (\text{CO}_2) &= X \\ (\text{H}_2\text{O}) &= Y \\ (\text{CH}_4) &= (\overline{\text{C}}) - (\overline{\text{O}}) + X + Y - Z \end{aligned}$$

$$\begin{aligned}
 (\text{CO}) &= (\bar{\text{O}}) - 2\text{X} - \text{Y} + \text{Z} \\
 (3.5 \text{ Cont'd}) (\text{H}_2) &= (1/2)(\bar{\text{H}}) - 2(\bar{\text{C}}) + 2(\bar{\text{O}}) - 2\text{X} - 3\text{Y} + 3\text{Z} \\
 (\text{Total}) &= (1/2)(\bar{\text{H}}) - (\bar{\text{C}}) + 2(\bar{\text{O}}) - 2\text{X} - 2\text{Y} + 3\text{Z} + (\text{Inerts})
 \end{aligned}$$

4. Calculation of Anode Exhaust Compositions (Oxidation in Fuel Cell Subsequent to Reforming Operation)

In these calculations, it is assumed that the reformer products are passed into the fuel cell, there to be subjected to oxidation by way of a given mechanism to a specified extent as shown in the table below.

Fuel Cell Reaction Scheme

	A	B	C	D
1	$\text{H}_2 + \text{O} \rightarrow \text{H}_2\text{O} + 2\text{e}^-$ Final x_{H_2} Specified	$\text{H}_2 + \text{CO}_3 \rightarrow \text{CO}_2 + \text{H}_2\text{O} + 2\text{e}^-$ Final x_{H_2} Specified	$\text{H}_2 \rightarrow 2\text{H}^+ + 2\text{e}^-$ Final x_{H_2} Specified	$\text{H}_2 \rightarrow 2\text{H}^+ + 2\text{e}^-$ Final x_{H_2} and Final Partial Pressure of Water Specified
2	$\text{H}_2 + \text{O} \rightarrow \text{H}_2\text{O} + 2\text{e}^-$ $\text{CO} + \text{O} \rightarrow \text{CO}_2 + 2\text{e}^-$ Final x_{H_2} and x_{CO} Specified	$\text{H}_2 + \text{CO}_3 \rightarrow \text{CO}_2 + \text{H}_2\text{O} + 2\text{e}^-$ $\text{CO} + \text{CO}_3 \rightarrow 2\text{CO}_2 + 2\text{e}^-$ Final x_{H_2} and x_{CO} Specified	$\text{H}_2 \rightarrow 2\text{H}^+ + 2\text{e}^-$ $\text{CO} + \text{H}_2\text{O} \rightarrow \text{CO}_2 + 2\text{H}^+ + 2\text{e}^-$ Final x_{H_2} and x_{CO} Specified	$\text{H}_2 \rightarrow 2\text{H}^+ + 2\text{e}^-$ $\text{CO} + \text{H}_2\text{O} \rightarrow \text{CO}_2 + 2\text{H}^+ + 2\text{e}^-$ Final x_{H_2} and Final Partial Pressure of Water Specified

In the above table:

x_{H_2} denotes mole fraction of molecular hydrogen

x_{CO} denotes mole fraction of carbon monoxide

In the expressions below the following definitions will apply:

a = moles of H_2 oxidized at anode

b = moles of CO oxidized at anode

W_A = moles of water added to (+) or removed from (-) anode compartment of fuel cell

p_{H_2O} = partial pressure of water (atmospheres)

P = total pressure (atmospheres)

The unknown can then be expressed in terms of the known quantities for the various schemes as follows:

Scheme A-1: $a = (H_2) - X_{H_2} \text{ (Total)}$

Scheme B-1: $a = \frac{(H_2) - X_{H_2} \text{ (Total)}}{X_{H_2} + 1}$

Scheme C-1: $a = \frac{(H_2) - X_{H_2} \text{ (Total)}}{1 - X_{H_2}}$

Scheme D-1: $a = \frac{P X_{H_2} [(H_2O) + (H_2) - (\text{Total})]}{(1 - X_{H_2})P - p_{H_2O}} + (H_2)$

$$W_A = \frac{p_{H_2O} [(\text{Total}) - a] - P (H_2O)}{P - p_{H_2O}}$$

Scheme A-2: $a = (H_2) - X_{H_2} \text{ (Total)}$

$b = (CO) - X_{CO} \text{ (Total)}$

Scheme B-2: $a = \frac{(X_{CO} + 1)(H_2) - X_{H_2} [(\text{Total}) + (CO)]}{1 + X_{H_2} + X_{CO}}$

$b = \frac{(X_{H_2} + 1)(CO) - X_{CO} [(\text{Total}) + (H_2)]}{1 + X_{H_2} + X_{CO}}$

Scheme C-2: $a = \frac{X_{H_2} [(CO) - (\text{Total})] + (1 - X_{CO})(H_2)}{1 - X_{H_2} - X_{CO}}$

$b = \frac{X_{CO} [(H_2) - (\text{Total})] + (1 - X_{H_2})(CO)}{1 - X_{H_2} - X_{CO}}$

Scheme D-2:

$$a = \frac{P X_{H_2} [(H_2O) + (H_2) - (\text{Total})]}{(1 - X_{H_2})P - p_{H_2O}} + (H_2)$$

$$b = \frac{P X_{CO} [(H_2O) + (H_2) - (\text{Total})]}{(1 - X_{H_2})P - p_{H_2O}} + (CO)$$

$$W_A = \frac{P[(H_2O) - b] - H_2O[(\text{Total}) - a - b]}{p_{H_2O} - P}$$

The electrical energy obtained from each scheme is given by

$$(4.1) \quad E(\text{kw-hr}) = (Z_a a + Z_b b) F \epsilon = 24.33(a + b)\epsilon$$

where E is the electrical energy, Z_a and Z_b are the number of equivalents per mole of hydrogen and carbon monoxide, respectively, F is the Faraday, and ϵ is the fuel cell voltage.

5. Calculation of Anode Exhaust Compositions (Fuel Cell Oxidation Concurrent With Reforming Operation)

In these calculations it is assumed that the oxidation and reforming processes occur in a single vessel and that the exhaust products satisfy the reforming and shift equilibria. The final mole fraction of hydrogen remaining unoxidized is specified as shown in the table below:

Fuel Cell Reaction Scheme

A	B	C
$3 H_2 + O^{\ominus} \rightarrow H_2O + 2e^-$ Final X_{H_2} Specified	$H_2 + CO_3^{\ominus} \rightarrow CO_2 + H_2O + 2e^-$ Final X_{H_2} Specified	$H_2 \rightarrow 2H^+ + 2e^-$ Final X_{H_2} Specified

It is evident that for each mole of hydrogen oxidized:

In Case A-3: a gram-atom of oxygen is gained.

In Case B-3: a gram-atom of carbon and 3 gram-atoms of oxygen are gained.

In Case C-3: 2 gram-atoms of hydrogen is lost.

The extent of the oxidation is determined by specifying X_{H_2} in the exhaust, where

$$(5.1) \quad X_{H_2} = \frac{(H_2)}{(\text{Total})}$$

Defining: (ΔO) as the number of gram-atoms of oxygen gained;
 (ΔC) as the number of gram-atoms of carbon gained; and
- (ΔH) as the number of gram-atoms of hydrogen lost.

The final composition of components can be expressed in terms of two unknowns, X and Y , by:

$$(CO_2) = X$$

$$(H_2O) = Y$$

$$(CH_4) = (C) - (O) + X + Y + (\Delta C) - (\Delta O)$$

$$(CO) = (O) - 2X - Y + (\Delta O)$$

$$(H_2) = (1/2)(H) - 2(C) + 2(O) - 2X - 3Y + (1/2)(\Delta H) \\ - 2(\Delta C) + 2(\Delta O)$$

$$(\text{Total}) = (1/2)(H) - (C) + 2(O) - 2X - 2Y + (\text{Inerts}) \\ + (1/2)(\Delta H) - (\Delta C) + 2(\Delta O)$$

The quantities (ΔO) , (ΔC) , and (ΔH) are functions of X and Y determined by equations (5.2).

For Case A-3:

$$(\Delta O) = \frac{[X_{H_2} - 1][(1/2)(H) - (C) + 2(O) - 2X - 2Y] + X_{H_2}(\text{Inerts}) + (C) + Y}{2(1 - X_{H_2})}$$

$$(\Delta C) = (\Delta H) = 0$$

For Case B-3:

$$(\Delta O) = \frac{3\{[X_{H_2} - 1][(1/2)(H) - (C) + 2(O) - 2X - 2Y] + X_{H_2}(\text{Inerts}) + (C) + Y\}}{4 - 5X_{H_2}}$$

$$(\Delta C) = 1/3(\Delta O); (\Delta H) = 0$$

For Case C-3:

$$\Delta H = \frac{2\{[X_{H_2} - 1][(1/2)(H) - (C) + 2(O) - 2X - 2Y] + X_{H_2} (\text{Inerts}) + (C) + Y\}}{1 - X_{H_2}}$$

$$\Delta O = \Delta C = 0$$

Since the components in the exhaust must also satisfy the reforming and shift equilibria, the expressions above are substituted into the equations (2.4) and these equations in two unknowns are solved by means of the Newton-Raphson method.

6. Calculation of Anode Exhaust Composition (Fuel Cell Oxidation Concurrent with Reforming Operation - Partial Recycle of Anode Exhaust)

In the following reaction schemes the oxidation and reforming processes occur simultaneously so that the anode exhaust products must satisfy the reforming and shift equilibria. Furthermore, it is assumed that an equilibrium has been established wherein a specified fraction, f , of the entire anode exhaust is recycled. As a result oxygen is not needed in the feed stock but is supplied during the oxidation process at the anode. In these calculations the final mole fraction of unoxidized hydrogen in the anode exhaust must be given.

Fuel Cell Reaction Scheme

A	B
$H_2 + O^{\cdot} \rightarrow H_2O + 2e^-$	$H_2 + CO_3^{\cdot} \rightarrow CO_2 + H_2O + 2e^-$
4 Final X_{H_2} and fraction, f , of anode exhaust recycle specified.	Final X_{H_2} and fraction, f , of anode exhaust recycle specified.

If the equilibrium anode exhaust composition is given by

$$(6.1) \quad \begin{cases} (C') & \text{gram-atoms of carbon} \\ (H') & \text{gram-atoms of hydrogen} \\ (O') & \text{gram-atoms of oxygen and} \\ (\text{Inerts}') & \text{moles of inerts} \end{cases}$$

then the feed composition is given by:

$$(6.2) \quad \begin{cases} (\bar{C}) + f(C') & \text{gram-atoms of carbon} \\ (\bar{H}) + f(H') & \text{gram-atoms of hydrogen} \\ f(O') & \text{gram-atoms of oxygen (no internal} \\ & \text{oxygen feed)} \\ (\bar{\text{Inerts}}) + f(\text{Inerts}') & \text{moles of inerts} \end{cases}$$

where f is the fraction of the exhaust recycled. The relations between feed and exhaust composition are:

$$(6.3) \quad \begin{cases} (H') & = (\bar{H}) + f(H') \\ (C') & = (\bar{C}) + f(C') + (\Delta C) \\ (O') & = f(O') + (\Delta O) \\ (\text{Inerts}') & = (\bar{\text{Inerts}}) + f(\text{Inerts}') \end{cases}$$

where (ΔC) and (ΔO) are the gram-atoms of carbon and oxygen picked up from the electrolyte in the course of oxidation at the anode.

Equations (6.3) lead directly to:

$$(6.4) \quad \begin{cases} (H') & = g(\bar{H}) \\ (C') & = g[(\bar{C}) + (\Delta C)] \\ (O') & = g(\Delta O) \\ (\text{Inerts}') & = g(\bar{\text{Inerts}}) \end{cases}$$

where $g = 1/(1 - f)$.

As in Section 5, the final composition of components can be expressed in terms of two unknowns:

$$(6.5) \quad \begin{cases} (CO_2) & = Y \\ (H_2O) & = Y \\ (CH_4) & = g[(\bar{C}) + (\Delta C) - (\Delta O)] + X + Y \\ (CO) & = g(\Delta O) - 2X - Y \end{cases}$$

$$(6.5) \quad \text{Cont'd} \quad \begin{cases} (H_2) &= g[(1/2)(\bar{H}) + 2(\Delta O) - 2(\bar{C}) - 2(\Delta C)] - 2X - 3Y \\ (\text{Total}) &= g[(1/2)(\bar{H}) + 2(\Delta O) - (\bar{C}) - (\Delta C) + (\text{Inerts})] \\ &\quad - 2X - 2Y \end{cases}$$

The quantities (ΔO) and (ΔC) are arrived at through:

$$(6.6) \quad X_{H_2} = \frac{(H_2)}{(\text{Total})}$$

Case A-4:

$$(\Delta O) = \frac{\{X_{H_2} - 1\} \{g[(1/2)(\bar{H}) - (\bar{C})] - 2X - 2Y\} + Y + g[(C) + X_{H_2}(\text{Inerts})]}{2g(1 - X_{H_2})}$$

$$(\Delta C) = 0$$

Case B-4:

$$(\Delta O) = \frac{3\{X_{H_2} - 1\} \{g[(1/2)(\bar{H}) - (\bar{C})] - 2X - 2Y\} + Y + g[(\bar{C}) + X_{H_2}(\text{Inerts})]}{g(4 - 5X_{H_2})}$$

$$(\Delta C) = 1/3(\Delta O)$$

Here again, the equations (2.4) must be satisfied and solution is obtained by means of the Newton-Raphson method.

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A P P E N D I X F

THEORETICAL PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

Appendix Tables F-1 to F-30 included in this section resulted from computer calculations described in Section X-C. These tables form the basis for figures, mainly for nonane, which are discussed in Section X-D-2b and for similar figures for other hydrocarbons which are given as Appendix Figures F-1 to F-22.

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TABLE F-1A
PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - CH₄ (100 MOLE % BASIS), STEAM/C RATIO, 1.0

P(ATM)	T(DEG F)	ELEMENTAL COMPOSITION				RT	EQUILIBRIUM PRODUCT COMPOSITIONS												TOTAL MOLES MOLE PC	
		C(ATM)	H(ATM)	O(ATM)	N2(MOLE %)		H2O	CO2	CH4	CO	H2	N2	MOLE	MOLE	MOLE	MOLE	MOLE	MOLE		
1.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	1.1866E 10	58.48	0.76	99.24	0.03	3.03	0.	0.	201.52	100.000	600.00	100.00	100.00	100.00	100.00	
1.0000	600.00	2.199CE-07	3.1479E 01	1.0438E 06	1.7857E 06	92.12	3.93	96.05	0.02	15.78	0.	0.	207.90	100.000	44.309	1.890	46.199	0.010	7.592	0.
1.0000	800.00	2.6585E-04	9.0223E 00	3.769CE 03	4.0015E 03	76.30	11.45	87.75	0.80	48.19	0.	0.	224.50	100.000	33.988	5.099	39.088	0.357	21.468	0.
1.0000	1000.00	4.901EE-02	3.7523E 00	6.4774E 01	4.6835E 01	52.16	18.83	70.99	10.18	105.87	0.	0.	258.42	100.000	20.215	7.297	27.512	3.947	41.029	0.
1.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	2.0204E 00	27.92	13.23	41.16	45.61	189.77	0.	0.	317.69	100.000	8.789	4.165	12.954	14.358	59.733	0.
1.0000	1400.00	6.3697E 01	1.2681E 00	2.730EE-01	2.3081E-01	10.84	4.09	14.93	80.98	259.31	0.	0.	370.14	100.000	2.928	1.105	4.033	21.879	70.055	0.
1.0000	1600.00	8.2135E 02	8.2439E-01	4.0069E-02	4.4509E-02	3.74	1.01	4.75	94.24	286.77	0.	0.	390.50	100.000	0.957	0.259	1.216	24.133	73.435	0.
1.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	1.167EE-02	1.40	0.28	1.68	98.03	295.23	0.	0.	396.63	100.000	0.353	0.071	0.425	24.716	74.435	0.
1.0000	2000.00	4.0514E 04	4.7516E-01	2.2622E-03	3.8254E-02	0.60	0.69	0.69	99.21	298.02	0.	0.	398.62	100.000	0.150	0.024	0.174	24.890	74.763	0.
1.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	1.4918E-03	0.29	0.04	0.32	99.64	259.07	0.	0.	399.35	100.000	0.672	0.009	0.081	24.950	74.888	0.
2.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	1.5367E 10	98.85	0.58	99.42	0.00	2.30	0.	0.	201.15	100.000	49.142	0.286	49.428	0.000	1.144	0.
2.0000	600.00	2.199CE-07	3.1479E 01	1.0438E 06	2.075CE 06	93.99	3.00	96.99	0.01	12.04	0.	0.	206.02	100.000	45.620	1.456	47.076	0.006	5.842	0.
2.0000	800.00	2.6585E-04	9.0223E 00	3.769CE 03	4.0015E 03	81.59	8.98	90.57	0.45	37.27	0.	0.	218.86	100.000	37.280	4.1C1	41.382	0.208	17.029	0.
2.0000	1000.00	4.901EE-02	3.7523E 00	6.4774E 01	5.6291E 01	61.20	16.41	77.61	5.97	83.58	0.	0.	244.78	100.000	25.002	6.7C6	31.7C8	2.441	34.144	0.
2.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	2.2587E 00	38.12	15.22	53.34	31.44	155.2L	0.	0.	293.32	100.000	12.995	5.189	18.185	10.718	52.912	0.
2.0000	1400.00	6.3697E 01	1.2681E 00	2.730EE-01	2.3866E-01	18.08	6.47	24.55	68.98	232.81	0.	0.	350.89	100.000	5.153	1.844	6.997	19.657	66.349	0.
2.0000	1600.00	8.2135E 02	8.2439E-01	4.0069E-02	4.487CE-02	7.0C	1.87	8.87	89.26	275.27	0.	0.	382.26	100.000	1.830	0.489	2.320	23.351	72.010	0.
2.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	1.17C4E-02	2.73	0.55	3.28	96.17	290.7L	0.	0.	393.43	100.000	0.655	0.140	0.835	24.443	73.888	0.
2.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	3.8281E-03	1.18	0.19	1.37	93.44	296.08	0.	0.	397.26	100.000	0.298	0.047	0.345	24.781	74.530	0.
2.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	1.4922E-03	0.57	0.07	0.64	99.28	298.14	0.	0.	398.71	100.000	0.143	0.019	0.161	24.901	74.776	0.
4.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	1.5846E 10	99.13	0.44	99.56	0.00	1.75	0.	0.	200.87	100.000	49.348	0.217	49.565	0.000	0.865	0.
4.0000	600.00	2.199CE-07	3.1479E 01	1.0438E 06	2.4046E 06	95.42	2.29	97.71	0.01	9.16	0.	0.	204.58	100.000	46.642	1.117	47.759	0.003	4.479	0.
4.0000	800.00	2.6585E-04	9.0223E 00	3.769CE 03	5.6068E 03	85.80	6.97	92.77	0.26	28.67	0.	0.	214.46	100.000	40.005	3.251	43.257	0.120	13.366	0.
4.0000	1000.00	4.901EE-02	3.7523E 00	6.4774E 01	6.7259E 01	69.08	13.73	82.81	3.46	65.29	0.	0.	234.38	100.000	29.475	5.858	35.333	1.476	27.859	0.
4.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	2.5773E 00	48.34	15.67	64.00	20.33	123.66	0.	0.	271.59	100.000	17.771	5.760	23.531	7.475	45.464	0.
4.0000	1400.00	6.3697E 01	1.2681E 00	2.730EE-01	2.3866E-01	18.08	6.47	24.55	68.98	232.81	0.	0.	350.89	100.000	5.153	1.844	6.997	19.657	66.349	0.
4.0000	1600.00	8.2135E 02	8.2439E-01	4.0069E-02	4.487CE-02	7.0C	1.87	8.87	89.26	275.27	0.	0.	382.26	100.000	1.830	0.489	2.320	23.351	72.010	0.
4.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	1.17C4E-02	2.73	0.55	3.28	96.17	290.7L	0.	0.	393.43	100.000	0.655	0.140	0.835	24.443	73.888	0.
4.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	3.8281E-03	1.18	0.19	1.37	93.44	296.08	0.	0.	397.26	100.000	0.298	0.047	0.345	24.781	74.530	0.
4.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	1.4922E-03	0.57	0.07	0.64	99.28	298.14	0.	0.	398.71	100.000	0.143	0.019	0.161	24.901	74.776	0.
4.0000	2400.00	2.199CE-07	3.1479E 01	1.0438E 06	2.4046E 06	95.42	2.29	97.71	0.01	9.16	0.	0.	204.58	100.000	46.642	1.117	47.759	0.003	4.479	0.
4.0000	2600.00	2.6585E-04	9.0223E 00	3.769CE 03	5.6068E 03	85.80	6.97	92.77	0.26	28.67	0.	0.	214.46	100.000	40.005	3.251	43.257	0.120	13.366	0.
4.0000	2800.00	4.901EE-02	3.7523E 00	6.4774E 01	6.7259E 01	69.08	13.73	82.81	3.46	65.29	0.	0.	234.38	100.000	29.475	5.858	35.333	1.476	27.859	0.
4.0000	3000.00	2.6875E 00	1.9714E 00	3.0042E 00	2.5773E 00	48.34	15.67	64.00	20.33	123.66	0.	0.	271.59	100.000	17.771	5.760	23.531	7.475	45.464	0.
4.0000	3200.00	6.3697E 01	1.2681E 00	2.730EE-01	2.3866E-01	18.08	6.47	24.55	68.98	232.81	0.	0.	350.89	100.000	5.153	1.844	6.997	19.657	66.349	0.
4.0000	3400.00	8.2135E 02	8.2439E-01	4.0069E-02	4.487CE-02	7.0C	1.87	8.87	89.26	275.27	0.	0.	382.26	100.000	1.830	0.489	2.320	23.351	72.010	0.
4.0000	3600.00	6.7984E 03	6.0833E-01	8.3445E-03	1.17C4E-02	2.73	0.55	3.28	96.17	290.7L	0.	0.	393.43	100.000	0.655	0.140	0.835	24.443	73.888	0.
4.0000	3800.00	4.0014E 04	4.7516E-01	2.2622E-03	3.8281E-03	1.18	0.19	1.37	93.44	296.08	0.	0.	397.26	100.000	0.298	0.047	0.345	24.781	74.530	0.
4.0000	4000.00	1.8036E 05	3.8864E-01	7.5373E-04	1.4922E-03	0.57	0.07	0.64	99.28	298.14	0.	0.	398.71	100.000	0.143	0.019	0.161	24.901	74.776	0.
4.0000	4200.00	2.199CE-07	3.1479E 01	1.0438E 06	2.4046E 06	95.42	2.29	97.71	0.01	9.16	0.	0.	204.58	100.000	46.642	1.117	47.759	0.003	4.479	0.
4.0000	4400.00	2.6585E-04	9.0223E 00	3.769CE 03	5.6068E 03	85.80	6.97	92.77	0.26	28.67	0.	0.	214.46	100.000	40.005	3.251	43.257	0.120	13.366	0.
4.0000	4600.00	4.901EE-02	3.7523E 00	6.4774E 01	6.7259E 01	69.08	13.73	82.81	3.46	65.29	0.	0.	234.38	100.000	29.475	5.858	35.333	1.476	27.859	0.
4.0000	4800.00	2.6875E 00	1.9714E 00	3.0042E 00	2.5773E 00	48.34	15.67	64.00	20.33	123.66	0.	0.	271.59	100.000	17.771	5.760	23.531	7.475	45.464	0.
4.0000	5000.00	6.3697E 01	1.2681E 00	2.730EE-01	2.3866E-01	18.08	6.47	24.55	68.98	232.81	0.	0.	350.89	100.000	5.153	1.844	6.997	19.657	66.349	0.
4.0000	5200.00	8.2135E 02	8.2439E-01	4.0069E-02	4.487CE-02	7.0C	1.87	8.87	89.26	275.27	0.	0.	382.26	100.000	1.830	0.489	2.320	23.351	72.010	0.
4.0000	5400.00	6.7984E 03	6.0833E-01	8.3445E-03	1.17C4E-02	2.73	0.55	3.28	96.17	290.7L	0.	0.	393.43	100.000	0.655	0.140	0.835	24.443</td		

TABLE F-1B

PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - CH₄ (100 MOLE % BASIS), STEAM/C RATIO, 1.0

TABLE F-2A
PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED = CH₄ (100 MOL % BASIS), STEAM/C RATIO = 2.0

P(MPa)	T(°F)	ELEMENTAL COMPOSITION				RT	EQUILIBRIUM PRODUCT COMPOSITIONS								TOTAL MOL %	
		C(ATOMS)	H(ATOMS)	O(ATOMS)	N2(MOLS)		H2O MOL PC	CO2 MOL PC	CH4 MOL PC	CO MOL PC	H2 MOL PC	N2 MOL PC	MOL %			
1.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	1.9419E-11	197.64 65.368	1.18 0.390	98.82 32.684	0.00 0.000	4.71 1.558	0. 0.	302.36 100.000				
1.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	2.9489E-06	187.73 60.111	6.12 1.961	93.85 30.051	0.03 0.008	24.57 7.868	0. 0.	312.36 100.000				
1.0000	800.00	2.6585E-04	9.0223E-00	3.7690E-03	7.0574E-03	162.75 48.125	18.16 5.369	80.91 23.925	0.93 0.276	75.43 22.305	0. 0.	338.18 100.000				
1.0000	1000.00	4.9018E-02	3.7523E-00	6.4774E-01	9.5129E-01	123.58 31.855	32.46 8.367	56.03 14.445	11.51 2.966	164.36 42.367	0. 0.	387.93 100.000				
1.0000	1200.00	2.6875E-00	1.9714E-00	3.0042E-06	6.0092E-07	88.32 19.172	31.33 6.801	19.66 4.267	49.01 10.639	272.36 59.121	0. 0.	460.69 100.000				
1.0000	1400.00	6.3697E-01	1.2081E-01	2.7306E-01	1.9882E-01	79.19 15.962	22.74 4.583	1.93 0.389	75.33 15.183	316.94 63.883	0. 0.	496.14 100.000				
1.0000	1600.00	8.2139E-02	8.2439E-01	4.0069E-02	1.3037E-02	82.52 16.515	17.63 3.529	0.15 0.031	82.21 16.452	317.17 63.473	0. 0.	499.69 100.000				
1.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	9.6844E-01	85.78 17.157	14.24 2.848	0.02 0.004	85.74 17.150	314.19 62.842	0. 0.	499.96 100.000				
1.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-02	7.6192E-01	88.16 17.632	11.84 2.368	0.00 0.001	88.15 17.631	311.83 62.367	0. 0.	499.99 100.000				
1.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	6.2661E-01	89.88 17.976	10.12 2.025	0.00 0.000	89.88 17.975	310.12 62.024	0. 0.	500.00 100.000				
2.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	2.1009E-12	198.21 65.680	0.89 0.296	99.11 32.840	0.00 0.000	3.57 1.184	0. 0.	301.79 100.000				
2.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	3.4026E-06	190.65 61.624	4.67 1.509	95.32 30.810	0.01 0.005	18.72 6.052	0. 0.	309.37 100.000				
2.0000	800.00	2.6585E-04	9.0223E-00	3.7690E-03	8.1867E-03	171.16 51.964	14.15 4.297	85.31 25.901	0.53 0.162	58.22 17.675	0. 0.	329.38 100.000				
2.0000	1000.00	4.9018E-02	3.7523E-00	6.4774E-01	1.1704E-02	138.36 37.545	27.39 7.432	65.75 17.841	6.87 1.863	130.15 35.318	0. 0.	368.51 100.000				
2.0000	1200.00	2.6875E-00	1.9714E-00	3.0042E-06	5.3623E-07	102.50 23.678	31.05 7.172	33.55 7.750	35.40 8.178	230.40 53.223	0. 0.	432.90 100.000				
2.0000	1400.00	6.3697E-01	1.2081E-01	2.7306E-01	1.1410E-01	83.08 17.046	23.24 4.768	6.32 1.296	70.45 14.454	304.29 62.435	0. 0.	487.37 100.000				
2.0000	1600.00	8.2139E-02	8.2439E-01	4.0069E-02	6.6059E-01	82.92 16.625	17.68 3.545	0.61 0.122	81.71 16.381	315.86 63.326	0. 0.	498.78 100.000				
2.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	4.8498E-01	85.83 17.170	14.25 2.850	0.07 0.015	85.68 17.141	314.03 62.824	0. 0.	499.85 100.000				
2.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-02	3.8106E-01	88.17 17.635	11.84 2.369	0.01 0.002	88.14 17.630	311.81 62.364	0. 0.	499.98 100.000				
2.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	3.1332E-01	89.88 17.976	10.12 2.025	0.00 0.001	89.87 17.975	310.12 62.024	0. 0.	499.99 100.000				
4.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	2.6528E-10	198.64 65.917	0.68 0.225	99.32 32.059	0.00 0.000	2.71 0.900	0. 0.	301.36 100.000				
4.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	3.9237E-06	192.88 62.802	3.56 1.158	96.44 31.400	0.01 0.003	14.25 4.638	0. 0.	307.13 100.000				
4.0000	800.00	2.6585E-04	9.0223E-00	3.7690E-03	9.4805E-03	177.80 55.130	10.95 3.395	88.75 27.518	0.31 0.095	44.71 13.863	0. 0.	322.51 100.000				
4.0000	1000.00	4.9018E-02	3.7523E-00	6.4774E-01	1.2217E-02	151.13 42.825	22.42 6.354	73.55 20.843	4.02 1.140	101.77 28.837	0. 0.	352.90 100.000				
4.0000	1200.00	2.6875E-00	1.9714E-00	3.0042E-06	5.3651E-07	118.11 29.136	29.20 7.234	47.31 11.671	23.49 5.794	187.27 46.196	0. 0.	405.38 100.000				

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TABLE F-2B

PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - CH₄ (100 MOLE C BASIS), STEAM/C RATIO 2.0

CALIFORNIA RESEARCH
CORPORATION
RICHMOND CALIFORNIA

TABLE F-3A

PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - CH₄ (100 MOLE % BASIS), STEAM/C RATIO 3.0

P(ATM)	T(DEG F)	ELEMENTAL COMPOSITIONS				RT	EQUILIBRIUM PRODUCT COMPOSITIONS							
		C(ATOMS) 100.00	H(ATOMS) 1000.00	O(ATOMS) 300.00	N2(MOLS) 0.		H2O MOL PC	CO2 MOL PC	CH4 MOL PC	CO MOL PC	H2 MOL PC	N2 MOL PC	TOTAL MOL PC	
1.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	2.4400E-10	296.89 73.651	1.55 0.385	98.45 24.422	0.00 0.000	6.22 1.542	0. 0.	403.11 100.000		
1.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	3.9241E-06	283.82 68.193	8.07 1.940	91.90 22.080	0.03 0.007	32.38 7.780	0. 0.	416.21 100.000		
1.0000	800.00	2.6585E-04	9.0223E-00	3.7690E-03	9.8449E-03	251.05 55.789	23.95 5.323	75.00 16.667	1.05 0.233	98.95 21.989	0. 0.	450.00 100.000		
1.0000	1000.00	4.9018E-02	3.7523E-00	6.4774E-01	1.5009E-02	200.73 39.248	43.54 8.514	44.28 8.657	12.18 2.382	210.71 41.199	0. 0.	511.45 100.000		
1.0000	1200.00	2.6875E-00	1.9714E-00	3.0042E-00	1.3233E-01	163.93 28.224	45.65 7.860	9.58 1.650	44.76 7.707	316.90 54.559	0. 0.	580.83 100.000		
1.0000	1400.00	6.3697E-01	1.2081E-00	2.7306E-01	5.6587E-00	173.74 1.347	36.89 6.162	0.63 0.105	62.48 10.435	335.01 55.952	0. 0.	598.74 100.000		
1.0000	1600.00	8.2139E-02	8.2439E-01	4.0069E-02	3.6417E-00	170.21 28.373	29.84 4.974	0.05 0.008	70.11 11.687	329.69 54.957	0. 0.	599.90 100.000		
1.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	2.6176E-00	175.29 29.215	24.72 4.120	0.01 0.001	75.27 12.546	324.70 54.118	0. 0.	599.99 100.000		
1.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	2.0120E-00	179.05 29.841	20.95 3.492	0.00 0.000	79.05 13.174	320.95 53.492	0. 0.	600.00 100.000		
1.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	1.6286E-00	181.83 30.304	18.17 3.029	0.00 0.000	81.83 13.638	318.17 53.029	0. 0.	600.00 100.000		
2.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	2.6075E-10	297.64 73.975	1.18 0.293	98.82 24.561	0.00 0.000	4.72 1.172	0. 0.	402.36 100.000		
2.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	4.5063E-06	287.67 69.763	6.16 1.493	93.83 22.754	0.02 0.004	24.68 5.985	0. 0.	412.35 100.000		
2.0000	800.00	2.6585E-04	9.0223E-00	3.7690E-03	1.1219E-04	262.05 59.755	18.67 4.257	80.72 18.467	0.60 0.138	76.50 17.443	0. 0.	438.55 100.000		
2.0000	1000.00	4.9018E-02	3.7523E-00	6.4774E-01	1.5929E-02	219.44 44.964	36.54 7.487	55.98 11.470	7.48 1.533	168.60 34.546	0. 0.	488.04 100.000		
2.0000	1200.00	2.6875E-00	1.9714E-00	3.0042E-00	9.8641E-03	177.22 31.761	43.79 7.849	21.01 3.766	35.19 6.307	280.76 50.318	0. 0.	557.98 100.000		
2.0000	1400.00	6.3697E-01	1.2081E-00	2.7306E-01	2.9671E-00	165.48 27.797	36.86 6.191	2.34 0.392	60.81 10.214	329.85 55.406	0. 0.	595.33 100.000		
2.0000	1600.00	8.2139E-02	8.2439E-01	4.0069E-02	1.8279E-01	170.36 28.412	29.84 4.977	0.20 0.033	69.96 11.668	329.25 54.911	0. 0.	599.60 100.000		
2.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	1.3094E-00	175.30 29.220	24.72 4.120	0.02 0.004	75.26 12.544	324.65 54.112	0. 0.	599.95 100.000		
2.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	1.0061E-00	179.05 29.842	20.95 3.492	0.03 0.001	79.04 13.174	320.94 53.491	0. 0.	599.99 100.000		
2.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	8.1429E-01	181.83 30.305	18.17 3.029	0.00 0.000	81.83 13.638	318.17 53.029	0. 0.	600.00 100.000		
4.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	3.1487E-10	298.21 74.221	0.89 0.223	99.11 24.666	0.09 0.000	3.58 0.890	0. 0.	401.79 100.000		
4.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	5.1764E-06	290.61 70.986	4.69 1.145	95.30 23.279	0.01 0.002	18.78 4.588	0. 0.	409.40 100.000		
4.0000	800.00	2.6585E-04	9.0223E-00	3.7690E-03	1.2829E-04	270.77 63.030	14.44 3.362	85.21 19.835	0.35 0.081	58.81 13.691	0. 0.	429.58 100.000		
4.0000	1000.00	4.9018E-02	3.7523E-00	6.4774E-01	1.7497E-02	235.91 50.348	29.81 6.363	65.72 14.026	4.47 0.953	132.65 28.310	0. 0.	468.56 100.000		
4.0000	1200.00	2.6875E-00	1.9714E-00	3.0042E-00	8.7533E-03	194.71 36.740	40.29 7.603	35.01 6.606	24.70 4.660	235.27 44.392	0. 0.	529.98 100.000		

CALIFORNIA RESEARCH
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RE 647648

TABLE F-3B

PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - CH₄ (100 MOL % BASIS), STEAM/C RATIO 3.0

ELEMENTAL COMPOSITION				EQUILIBRIUM PRODUCT COMPOSITIONS									
C (ATMOS)	H (ATOMS)	O (ATMOS)	N ₂ (MOLS)	RT	H ₂ O	CO ₂	CH ₄	CO	H ₂	N ₂	TOTAL	MOL MOL	MOL MOL
100.00	100.00	300.00	0.	MOL PC	MOL PC	MOL PC	MOL PC	MOL PC	MOL PC	MOL PC	MOL MOL	MOL PC	MOL PC
CONDITIONS AND EQUILIBRIUM CONSTANTS	KR	KS	KC	RT	H ₂ O	CO ₂	CH ₄	CO	H ₂	N ₂	TOTAL	MOL MOL	MOL MOL
P (ATM) T (DEG F)					MOL PC	MOL PC	MOL PC	MOL PC	MOL PC	MOL PC	MOL MOL	MOL PC	MOL PC
4.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	1.7186E 06	170.78 29.188	36.68 6.268	7.45 1.274	55.87 9.549	314.31 53.720	0. 0.	585.09 100.00	
4.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	9.2781E-01	170.93 28.562	29.85 4.988	0.78 0.130	69.38 11.593	327.52 54.728	0. 0.	598.45 100.000	
4.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	6.5586E-01	175.37 29.238	24.72 4.122	0.10 0.016	75.18 12.534	324.43 54.090	0. 0.	599.81 100.000	
4.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	5.0320E-01	179.06 29.845	20.95 3.492	0.02 0.003	79.03 13.172	320.90 53.487	0. 0.	599.97 100.000	
4.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	4.0717E-01	181.83 30.305	18.17 3.029	0.00 0.001	81.82 13.637	318.16 53.028	0. 0.	599.99 100.000	
6.0000	400.00	7.9414E-12	2.0711E-02	4.00007E-09	3.4972E-10	298.48 74.337	0.76 0.189	99.24 24.716	0.00 0.000	3.04 0.738	0. 0.	401.52 100.000	
6.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	5.6118E 06	292.00 71.568	4.00 0.979	96.00 23.529	0.01 0.012	16.00 3.922	0. 0.	408.00 100.000	
6.0000	800.00	2.6585E-04	9.0223E 00	3.7690E-03	1.3888E-04	274.96 64.651	12.40 2.915	87.35 20.539	0.25 0.059	50.34 11.836	0. 0.	425.29 100.000	
6.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	1.8658E 02	244.31 53.230	26.21 5.710	70.52 15.364	3.28 0.714	114.66 24.982	0. 0.	458.97 100.000	
6.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	8.6222E 00	205.52 40.000	37.58 7.314	43.10 8.388	19.32 3.760	208.28 40.538	0. 0.	513.80 100.000	
6.0000	1400.0	6.3697E 01	1.2081E 00	2.7306E-01	1.3539E 00	176.60 30.762	36.35 6.333	12.96 2.257	50.69 8.829	297.48 51.818	0. 0.	574.08 100.000	
6.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	6.3342E-01	171.82 28.799	29.86 5.004	1.68 0.282	68.46 11.475	324.81 54.441	0. 0.	596.64 100.000	
6.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	4.3854E-01	175.49 29.269	24.73 4.124	0.21 0.036	75.06 12.519	324.08 54.052	0. 0.	599.57 100.000	
6.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	3.3563E-01	179.08 29.851	20.95 3.493	0.04 0.006	79.01 13.170	320.84 53.481	0. 0.	599.93 100.000	
6.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	2.7148E-01	181.83 30.307	18.17 3.029	0.01 0.001	81.82 13.637	318.15 53.026	0. 0.	599.98 100.000	
12.0000	400.00	7.9414E-12	2.0711E-02	4.00007E-09	5.2986E-10	298.85 74.497	0.58 0.144	99.42 24.784	0.00 0.000	2.31 0.575	0. 0.	401.15 100.000	
12.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	6.4549E 06	293.92 72.380	3.04 0.748	96.96 23.877	0.00 0.001	12.16 2.994	0. 0.	406.08 100.000	
12.0000	800.00	2.6585E-04	9.0223E 00	3.7690E-03	1.5922E-04	280.83 66.974	9.51 2.269	90.34 21.545	0.14 0.034	38.48 9.178	0. 0.	419.31 100.000	
12.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	2.1023E 02	256.57 57.611	20.76 4.661	77.33 17.363	1.91 0.430	88.78 19.935	0. 0.	445.35 100.000	
12.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	8.8992E 00	223.24 45.659	32.30 6.607	95.54 11.359	12.16 2.487	165.69 33.888	0. 0.	488.92 100.000	
12.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	1.0529E 06	191.03 34.865	35.00 6.388	26.04 4.752	38.96 7.111	256.89 46.885	0. 0.	547.93 100.000	
12.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	3.5260E-01	175.81 29.868	29.86 5.073	5.68 0.965	64.46 10.950	312.83 53.144	0. 0.	588.64 100.000	
12.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	2.2273E-01	176.10 29.431	24.74 4.135	0.84 0.140	74.42 12.438	322.23 53.855	0. 0.	598.33 100.000	
12.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	1.6826E-01	179.19 29.879	20.96 3.495	0.15 0.024	78.90 13.156	320.52 53.446	0. 0.	599.71 100.000	
12.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	1.3502E-01	181.86 30.313	18.17 3.029	0.03 0.005	81.79 13.634	318.08 53.019	0. 0.	599.94 100.000	

TABLE F-4A

PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - CH₄ (100 MOLE % BASIS), STEAM/C RATIO 4.0

ELEMENTAL COMPOSITION				EQUILIBRIUM PRODUCT COMPOSITIONS											
C(ATOMS)	H(ATOMS)	O(ATOMS)	N2(MOLS)	CONDITIONS AND EQUILIBRIUM CONSTANTS			RT	H2O MOLS MOL PC	CO2 MOLS MOL PC	CH4 MOLS MOL PC	CO MOLS MOL PC	H2 MOLS MOL PC	N2 MOLS MOL PC	TOTAL MOLS MOL PC	
100.00	1200.00	400.00	0.	P(ATM)	T(DEG F)	KR	Ks	KC	RT	H2O MOLS MOL PC	CO2 MOLS MOL PC	CH4 MOLS MOL PC	CO MOLS MOL PC	H2 MOLS MOL PC	N2 MOLS MOL PC
1.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	3.1173E 10	396.19	1.91	98.09	0.00	7.62	0.	503.81	100.00		
1.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	4.7995E 06	78.639	0.378	19.471	0.000	1.513	0.	519.83	100.00		
1.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	1.2549E 04	380.20	9.88	90.09	0.03	39.62	0.	519.83	100.00		
1.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	2.1600E 02	73.140	1.901	17.330	0.006	7.623	0.	519.83	100.00		
1.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	1.2549E 04	340.48	29.19	69.67	1.14	120.18	0.	560.66	100.00		
1.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	1.1702E 01	60.728	5.206	12.426	0.204	21.436	0.	630.52	100.00		
1.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	7.2773E 03	281.90	52.84	34.74	12.42	248.62	0.	690.24	100.00		
1.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	5.0885E 00	44.709	8.380	5.510	1.970	39.431	0.	699.45	100.00		
1.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	3.8374E 00	248.80	56.08	4.88	39.04	341.45	0.	699.45	100.00		
1.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	3.0647E 00	36.045	8.125	0.707	5.656	49.467	0.	699.45	100.00		
1.0000	2400.00	8.2139E 02	8.2439E-01	4.0069E-02	7.2773E 03	253.46	46.82	0.28	52.90	345.99	0.	699.45	100.00		
1.0000	2600.00	6.7984E 03	6.0833E-01	8.3445E-03	5.0885E 00	36.237	6.694	0.040	7.563	49.466	0.	699.45	100.00		
1.0000	2800.00	4.0014E 04	4.7516E-01	2.2622E-03	3.8374E 00	261.17	38.85	0.02	61.13	338.78	0.	699.45	100.00		
1.0000	3000.00	1.8036E 05	3.8864E-01	7.5373E-04	3.0647E 00	37.313	5.550	0.003	8.733	48.400	0.	699.45	100.00		
1.0000	3200.00	8.2139E 02	8.2439E-01	4.0069E-02	7.2773E 03	267.19	32.81	0.00	67.18	332.80	0.	699.45	100.00		
1.0000	3400.00	6.7984E 03	6.0833E-01	8.3445E-03	5.0885E 00	38.170	4.688	0.000	9.598	47.544	0.	699.45	100.00		
1.0000	3600.00	4.0014E 04	4.7516E-01	2.2622E-03	3.8374E 00	38.824	4.033	0.000	10.252	46.890	0.	700.00	100.00		
1.0000	3800.00	1.8036E 05	3.8864E-01	7.5373E-04	3.0647E 00	275.22	24.78	0.00	75.22	324.77	0.	700.00	100.00		
1.0000	4000.00	8.2139E 02	8.2439E-01	4.0069E-02	7.2773E 03	39.318	3.539	0.000	10.746	46.396	0.	700.00	100.00		
2.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	3.4263E 10	397.11	1.45	98.55	0.00	5.78	0.	502.89	100.00		
2.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	4.7995E 06	78.965	0.287	19.598	0.000	1.150	0.	515.12	100.00		
2.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	1.4076E 04	384.90	7.54	92.44	0.02	30.22	0.	546.92	100.00		
2.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	2.1619E 02	64.680	1.464	17.945	0.004	5.866	0.	604.77	100.00		
2.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	1.6516E 01	253.75	22.79	76.54	0.67	93.17	0.	673.90	100.00		
2.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	5.9785E 00	38.172	4.168	13.995	0.122	17.036	0.	697.85	100.00		
2.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	3.6444E 00	261.25	38.84	0.09	61.07	338.57	0.	699.82	100.00		
2.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	2.5448E 00	37.330	4.688	0.002	9.597	47.541	0.	699.82	100.00		
2.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	1.9187E 00	38.172	267.20	32.81	67.18	332.78	0.	700.00	100.00		
2.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	1.5324E 00	38.824	4.033	0.000	10.252	46.890	0.	700.00	100.00		
2.0000	2400.00	8.2139E 02	8.2439E-01	4.0069E-02	3.6444E 00	275.23	24.78	0.00	75.22	324.77	0.	700.00	100.00		
2.0000	2600.00	6.7984E 03	6.0833E-01	8.3445E-03	2.5448E 00	39.318	3.539	0.000	10.746	46.396	0.	700.00	100.00		
2.0000	2800.00	4.0014E 04	4.7516E-01	2.2622E-03	1.9187E 00	39.318	1.10	98.90	0.00	4.39	0.	502.19	100.00		
2.0000	3000.00	1.8036E 05	3.8864E-01	7.5373E-04	1.5324E 00	39.318	0.218	19.694	0.000	0.873	0.	511.51	100.00		
2.0000	3200.00	8.2139E 02	8.2439E-01	4.0069E-02	3.6444E 00	39.318	5.74	94.24	0.01	23.01	0.	536.08	100.00		
2.0000	3400.00	6.7984E 03	6.0833E-01	8.3445E-03	2.5448E 00	39.318	1.123	18.425	0.002	4.498	0.	536.08	100.00		
2.0000	3600.00	4.0014E 04	4.7516E-01	2.2622E-03	1.9187E 00	39.318	17.66	81.96	0.39	71.78	0.	582.40	100.00		
2.0000	3800.00	1.8036E 05	3.8864E-01	7.5373E-04	1.5324E 00	39.318	67.957	3.293	15.289	0.072	13.389	0.	648.62	100.00	
2.0000	4000.00	8.2139E 02	8.2439E-01	4.0069E-02	3.6444E 00	39.318	322.42	36.39	58.80	4.81	159.98	0.	648.62	100.00	
2.0000	4200.00	6.7984E 03	6.0833E-01	8.3445E-03	2.5448E 00	39.318	55.360	6.248	10.097	0.826	27.469	0.	648.62	100.00	
2.0000	4400.00	4.0014E 04	4.7516E-01	2.2622E-03	1.9187E 00	42.577	276.16	49.53	25.69	24.79	272.46	0.	648.62	100.00	
2.0000	4600.00	1.8036E 05	3.8864E-01	7.5373E-04	1.5324E 00	42.577	7.636	3.960	3.821	42.006	0.	648.62	100.00		

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TABLE F-4B

PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - CH₄ (100 MOL % BASIS), STEAM/C RATIO = 4.0

T(ATOMS)	ELEMENTAL COMPOSITION			RT	EQUILIBRIUM PRODUCT COMPOSITIONS								TOTAL MOLS MOL PC
	H(ATOMS)	C(ATOMS)	N2(MOLS)		H2O MOLS MOL PC	CO2 MOLS MOL PC	CH4 MOLS MOL PC	CO MOLS MOL PC	H2 MOLS MOL PC	N2 MOLS MOL PC			
CONDITIONS AND EQUILIBRIUM CONSTANTS													
T(DEG F)	KR	KS	KC										
4.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	3.2244E 01	257.49 37.189	46.32 6.690	3.81 0.550	49.87 7.202	354.89 48.368	0. 0.	692.38 100.000	
4.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	1.0349E 01	261.53 37.400	38.82 5.552	0.36 0.051	60.82 8.697	337.75 48.330	0. 0.	699.29 100.000	
4.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	1.2734E 01	267.23 38.181	32.81 4.688	0.04 0.006	67.14 9.593	332.68 47.531	0. 0.	699.91 100.000	
4.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	9.5950E-01	271.77 38.826	28.23 4.033	0.01 0.001	71.76 10.251	328.21 46.888	0. 0.	699.98 100.000	
4.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	7.6621E-01	275.23 39.318	24.78 3.539	0.00 0.000	75.22 10.746	324.77 46.396	0. 0.	699.99 100.000	
6.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	4.4306E 10	398.13 79.331	0.93 0.186	99.07 19.740	0.01 0.000	3.73 0.743	0. 0.	501.87 100.000	
6.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	6.8090E 06	390.20 76.539	4.90 0.960	95.10 18.653	0.01 0.002	19.61 3.846	0. 0.	509.81 100.000	
6.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	1.7147E 04	369.40 69.582	15.16 2.856	84.56 15.928	0.28 0.053	61.48 11.582	0. 0.	530.88 100.000	
6.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	2.4029E 02	332.41 58.199	32.02 5.605	64.42 11.279	3.56 0.624	138.75 24.292	0. 0.	571.15 100.000	
6.0000	1200.00	2.6875E 00	1.9714E 03	3.0042E 09	1.2276E 01	287.71 45.509	46.19 7.306	33.90 5.362	19.91 3.149	244.49 38.673	0. 0.	632.20 100.000	
6.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	2.3767E 03	261.55 38.163	45.77 6.679	7.33 1.069	46.90 6.844	323.80 47.246	0. 0.	685.35 100.000	
6.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	1.2369E 01	262.00 37.513	38.79 5.554	0.79 0.113	60.42 8.651	336.42 48.169	0. 0.	698.42 100.000	
6.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	8.501CE-01	267.29 38.195	32.81 4.688	0.10 0.014	67.09 9.587	332.51 47.515	0. 0.	699.80 100.000	
6.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	6.3981E-01	271.78 38.828	28.23 4.034	0.02 0.002	71.75 10.250	328.18 46.885	0. 0.	699.97 100.000	
6.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	5.1083E-01	275.23 39.319	24.78 3.539	0.00 0.001	75.22 10.746	324.76 46.395	0. 0.	699.99 100.000	
12.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	4.1445E 10	398.59 79.492	0.71 0.141	99.29 19.803	0.00 0.000	2.83 0.564	0. 0.	501.41 100.000	
12.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	7.8086E 06	392.55 77.357	3.72 0.734	96.27 18.972	0.00 0.001	14.90 2.937	0. 0.	507.45 100.000	
12.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	1.9530E 04	376.55 71.914	11.64 2.224	88.19 16.844	0.16 0.031	47.06 8.988	0. 0.	523.61 100.000	
12.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	2.6566E 02	347.12 62.546	25.39 4.575	72.51 13.065	2.10 0.379	107.87 19.436	0. 0.	554.98 100.000	
12.0000	1200.00	2.6875E 00	1.9714E 03	3.0042E 09	1.1980E 01	307.69 50.837	39.69 6.558	47.38 7.828	12.93 2.136	197.55 32.640	0. 0.	605.24 100.000	
12.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	1.6370E 01	273.87 41.207	43.81 6.592	17.69 2.661	38.50 5.793	290.76 43.747	0. 0.	664.63 100.000	
12.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	6.5311E-01	264.27 38.068	38.62 5.563	2.89 0.417	58.49 8.425	329.94 47.528	0. 0.	694.22 100.000	
12.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	4.2813E-01	267.60 38.271	32.80 4.690	0.39 0.056	66.81 9.555	331.61 47.427	0. 0.	699.21 100.000	
12.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	3.2030E-01	271.84 38.841	28.23 4.034	0.07 0.010	71.70 10.245	328.03 46.870	0. 0.	699.86 100.000	
12.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	2.5548E-01	275.24 39.322	24.78 3.539	0.02 0.002	75.21 10.745	324.73 46.392	0. 0.	699.97 100.000	

TABLE F-5A
PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA
STEAM REFORMER FEED - CH₄ (100 MOLE % BASIS), STEAM/C RATIO 5.0

P(ATM)	T(DEG F)	CONDITIONS AND EQUILIBRIUM CONSTANTS			RF	EQUILIBRIUM PRODUCT COMPOSITIONS								TOTAL MOLES MOL PC
		KR	KS	KC		H ₂ O MOLES MOL PC	CO ₂ MOLES MOL PC	CH ₄ MOLES MOL PC	CO MOLES MOL PC	H ₂ MOLES MOL PC	N ₂ MOLES MOL PC			
1.0000	400.0	7.9414E-12	2.0711E 02	4.0007E 09	3.5767E 10	495.52 81.975	2.24 0.310	97.76 16.173	0.01 0.000	8.96 1.482	0. 0.	604.48 100.000		
1.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	5.6391E 06	476.79 76.500	11.59 1.859	88.37 14.180	0.04 0.006	46.46 7.455	0. 0.	623.25 100.000		
1.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	1.5255E 04	430.76 64.247	34.01 5.073	64.77 9.660	1.22 0.182	139.71 20.838	0. 0.	670.47 100.000		
1.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	2.9717E 02	366.35 49.109	60.66 8.131	27.00 3.620	12.34 1.654	279.65 37.487	0. 0.	745.99 100.000		
1.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 06	4.4187E 01	339.09 42.668	63.55 7.997	2.64 0.332	33.81 4.254	355.63 44.749	0. 0.	794.72 100.000		
1.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	2.0659E 01	346.05 43.272	54.10 6.764	0.14 0.018	45.76 5.722	353.66 44.224	0. 0.	799.71 100.000		
1.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	1.2465E 01	354.23 44.280	45.78 5.723	0.01 0.002	54.21 6.776	345.73 43.220	0. 0.	799.98 100.000		
1.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	8.5212E 00	360.73 45.091	39.28 4.909	0.00 0.000	60.72 7.590	339.27 42.409	0. 0.	800.00 100.000		
1.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	6.3240E 00	365.79 45.723	34.21 4.277	0.00 0.000	65.79 8.223	334.21 41.776	0. 0.	800.00 100.000		
1.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	4.9934E 00	369.69 46.211	30.31 3.789	0.00 0.000	69.69 8.711	330.31 41.289	0. 0.	800.00 100.000		
2.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	3.9148E 10	496.60 82.301	1.70 0.282	98.3L 16.291	0.00 0.000	6.80 1.127	0. 0.	603.40 100.000		
2.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	5.3946E 06	482.28 78.071	8.85 1.433	91.13 14.752	0.02 0.003	35.46 5.741	0. 0.	617.74 100.000		
2.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	1.6854E 04	446.02 68.126	26.63 4.068	72.65 11.097	0.72 0.110	108.68 16.600	0. 0.	654.70 100.000		
2.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	2.7999E 02	388.86 54.062	51.50 7.161	40.36 5.611	8.13 1.131	230.42 32.035	0. 0.	719.28 100.000		
2.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 06	2.6169E 01	346.61 44.225	61.52 7.849	8.13 1.037	30.35 3.873	337.13 43.015	0. 0.	783.74 100.000		
2.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	1.0448E 01	346.56 43.382	54.00 6.759	0.56 0.071	45.44 5.688	352.31 44.101	0. 0.	798.87 100.000		
2.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	0.2383E 01	354.27 44.289	45.78 5.723	0.05 0.006	54.17 6.773	345.63 43.229	0. 0.	799.90 100.000		
2.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	4.2611E 00	360.73 45.092	39.27 4.909	0.01 0.001	60.72 7.590	339.26 42.408	0. 0.	799.99 100.000		
2.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	1.1621E 00	365.79 45.724	34.21 4.277	0.00 0.000	65.79 8.223	334.21 41.776	0. 0.	800.00 100.000		
2.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	2.4967E 00	369.69 46.211	30.31 3.789	0.00 0.000	69.69 8.711	330.31 41.289	0. 0.	800.00 100.000		
4.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	3.1479E 10	497.42 82.549	1.29 0.214	98.71 16.381	0.00 0.000	5.16 0.896	0. 0.	602.58 100.000		
4.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	7.3336E 06	486.50 79.297	6.75 1.099	93.24 15.198	0.01 0.002	27.02 4.434	0. 0.	613.51 100.000		
4.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	1.8861E 04	458.25 71.301	20.66 3.218	78.92 12.289	0.42 0.065	83.91 13.067	0. 0.	642.17 100.000		
4.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	1.8844E 02	412.26 59.045	42.33 6.093	57.59 7.569	5.08 0.730	184.56 26.563	0. 0.	694.82 100.000		
4.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 06	1.8661E 01	361.51 47.402	57.17 7.496	18.68 2.449	24.16 3.167	301.14 39.486	0. 0.	762.65 100.000		

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TABLE F-5B

PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - CH₄ (100 MOLE % BASIS), STEAM/C RATIO 5.0

ELEMENTAL COMPOSITION											
C(ATOMS)	H(ATOMS)	O(ATOMS)	N2(MOLS)								
100.00	1400.00	500.00	0.								
CONDITIONS AND EQUILIBRIUM CONSTANTS											
P(ATM)	T(DEG F)	KR	KS	KC	RT	H ₂ O MOLS MOL PC	CO ₂ MOLS MOL PC	CH ₄ MOLS MOL PC	EQUILIBRIUM PRODUCT COMPOSITIONS CD H ₂ N ₂ TOTAL MOLS MOL PC		
						MOLS MOL PC	MOLS MOL PC	MOLS MOL PC	MOLS MOL PC		
4.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	5.4499E 00	348.47 43.790	53.64 6.741	2.11 0.265	44.25 5.561	347.31 43.644 0.	795.78 100.000
4.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	3.1306E 00	354.44 44.326	45.76 5.722	0.19 0.024	54.05 6.760	345.18 43.168 0.	799.62 100.000
4.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	2.1315E 00	360.75 45.097	39.27 4.909	0.02 0.003	60.70 7.588	339.20 42.403 0.	799.95 100.000
4.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	1.5811E 00	365.79 45.724	34.21 4.277	0.00 0.001	65.78 8.223	334.20 41.775 0.	799.99 100.000
4.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	1.2484E 00	369.69 46.211	30.31 3.789	0.00 0.000	69.69 8.711	330.31 41.289 0.	800.00 100.000
6.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	4.4755E 10	497.81 82.666	1.10 0.182	98.90 16.424	0.00 0.000	4.39 0.728 0.	602.19 100.000
6.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	7.8994E 06	488.49 79.882	5.75 0.940	94.24 15.411	0.01 0.001	23.03 3.766 0.	611.52 100.000
6.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	2.0225E 04	464.18 72.969	17.76 2.792	81.94 12.880	0.31 0.048	71.95 11.311 0.	636.13 100.000
6.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	2.9520E 02	421.55 61.790	37.33 5.471	58.88 8.631	3.79 0.556	160.68 23.552 0.	682.24 100.000
6.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	1.6722E 01	372.92 49.919	53.55 7.169	26.48 3.544	19.97 2.673	274.13 36.695 0.	747.05 100.000
6.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	3.8634E 00	351.20 44.378	53.11 6.711	4.31 0.544	42.58 5.381	340.19 42.986 0.	791.38 100.000
6.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	2.0996E 00	354.71 44.385	45.72 5.721	0.43 0.053	53.85 6.739	344.44 43.101 0.	799.15 100.000
6.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	1.4220E 00	360.78 45.104	39.27 4.909	0.05 0.007	60.68 7.585	339.11 42.394 0.	799.89 100.000
6.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	1.0542E 00	365.80 45.726	34.21 4.277	0.01 0.001	65.78 8.223	334.18 41.774 0.	799.98 100.000
6.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	8.3227E-01	369.69 46.211	30.31 3.789	0.00 0.000	69.69 8.711	330.31 41.288 0.	800.00 100.000
12.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	5.8476E 10	498.34 82.827	0.83 0.138	99.17 16.482	0.00 0.000	3.33 0.553 0.	601.66 100.000
12.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	9.0358E 06	491.25 80.697	4.37 0.718	95.62 15.708	0.00 0.001	17.51 2.876 0.	608.76 100.000
12.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	2.2896E 04	472.52 75.282	13.65 2.175	86.17 13.729	0.18 0.028	55.14 8.786 0.	627.66 100.000
12.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	3.2023E 02	438.38 66.033	29.68 4.470	68.06 10.251	2.26 0.341	125.50 18.904 0.	663.88 100.000
12.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	1.5405E 01	394.06 54.779	46.26 6.431	40.32 5.605	13.42 1.865	225.30 31.320 0.	719.36 100.000
12.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	2.4248E 00	360.92 46.512	51.08 6.583	12.01 1.547	36.91 4.756	315.06 40.601 0.	775.99 100.000
12.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	1.0827E 00	356.09 44.692	45.54 5.715	1.62 0.203	52.84 6.632	340.67 42.757 0.	796.76 100.000
12.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	7.1384E-01	360.96 45.145	39.25 4.909	0.22 0.027	60.53 7.570	338.61 42.349 0.	799.57 100.000
12.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	5.2747E-01	365.83 45.733	34.21 4.277	0.04 0.005	65.75 8.220	334.10 41.766 0.	799.92 100.000
12.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	4.1620E-01	369.70 46.213	30.31 3.789	0.01 0.001	69.68 8.710	330.29 41.287 0.	799.98 100.000

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TABLE F-6

PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - C3H8 (100 MOL % BASIS), STEAM/C RATIO, 1.0

P(ATM)	T(DEG F)	ELEMENTAL COMPOSITION			RT	EQUILIBRIUM PRODUCT COMPOSITIONS								TOTAL MOLS MOL PC
		C(ATOMS) 100.00	H(ATOMS) 466.67	O(ATOMS) 100.00		H2O MOLS MOL PC	CO2 MOLS MOL PC	CH4 MOLS MOL PC	CO MOLS MOL PC	H2 MOLS MOL PC	N2 MOLS MOL PC			
1.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	3.7857E-02	2.98 0.916	1.05 0.322	4.03 1.238	94.92 29.182	222.39 68.341	0. 0.	325.28 100.00		
		CONDITIONS LEAD TO CARBON FORMATION.												
1.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	1.0038E-02	1.13 0.341	0.29 0.089	1.42 0.429	98.29 29.739	229.37 69.402	0. 0.	330.51 100.00		
1.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	3.3068E-03	0.48 0.145	0.10 0.030	0.58 0.175	99.32 29.900	231.69 69.750	0. 0.	332.17 100.00		
1.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	1.2941E-03	0.23 0.070	0.04 0.012	0.27 0.081	99.69 29.956	232.56 69.882	0. 0.	332.79 100.00		
2.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	3.7939E-02	5.57 1.749	1.95 0.614	7.52 2.363	90.52 28.441	212.72 66.833	0. 0.	318.29 100.00		
		CONDITIONS LEAD TO CARBON FORMATION.												
2.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	1.0039E-02	2.20 0.670	0.57 0.175	2.77 0.844	96.66 29.488	225.60 68.824	0. 0.	327.80 100.00		
2.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	3.3063E-03	0.95 0.288	0.19 0.059	1.15 0.347	98.66 29.802	230.08 69.504	0. 0.	331.44 100.00		
2.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	1.2939E-03	0.46 0.139	0.08 0.023	0.54 0.162	99.38 29.912	231.80 69.764	0. 0.	332.26 100.00		
4.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	3.8088E-02	9.87 3.219	3.44 1.122	13.31 4.341	83.24 27.141	196.83 64.176	0. 0.	306.71 100.00		
		CONDITIONS LEAD TO CARBON FORMATION.												
4.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	1.0041E-02	4.19 1.297	1.09 0.338	5.28 1.635	93.63 29.008	218.59 67.722	0. 0.	322.78 100.00		
4.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	3.3053E-03	1.87 0.569	0.38 0.116	2.25 0.685	97.37 29.610	226.96 69.021	0. 0.	328.53 100.00		
4.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	1.2936E-03	0.91 0.276	0.15 0.046	1.07 0.322	98.78 29.825	230.29 69.531	0. 0.	331.21 100.00		
6.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	3.8221E-02	13.33 4.482	4.62 1.554	17.95 6.036	77.42 26.031	184.10 61.896	0. 0.	297.43 100.00		
		CONDITIONS LEAD TO CARBON FORMATION.												
6.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	1.0042E-02	6.00 1.886	1.56 0.491	7.57 2.378	90.87 28.557	212.24 66.687	0. 0.	318.29 100.00		
6.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	3.3044E-03	2.75 0.842	0.56 0.172	3.31 1.013	96.13 29.423	223.96 68.551	0. 0.	326.71 100.00		
6.0000	2200.0	1.8.36E 05	3.8864E-01	7.5373E-04	1.2933E-03	1.36 0.411	0.23 0.069	1.59 0.480	98.19 29.739	228.81 69.301	0. 0.	330.16 100.00		
12.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	3.8558E-02	20.69 7.446	7.07 2.546	27.76 9.992	65.17 23.457	157.13 56.559	0. 0.	277.82 100.00		
		CONDITIONS LEAD TO CARBON FORMATION.												
12.0000	1800.0	6.7984E 03	6.0833E-01	8.3445E-03	1.0046E-02	10.62 3.465	2.76 0.902	13.39 4.366	83.85 27.351	195.94 63.916	0. 0.	306.56 100.00		
12.0000	2000.0	4.0014E 04	4.7516E-01	2.2622E-03	3.3016E-03	5.19 1.619	1.06 0.331	6.26 1.950	92.68 28.889	215.63 67.211	0. 0.	320.82 100.00		
12.0000	2200.0	1.8036E 05	3.8864E-01	7.5373E-04	1.2923E-03	2.64 0.807	0.44 0.135	3.08 0.942	96.48 29.488	224.53 68.627	0. 0.	327.17 100.00		

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TABLE F-7A
PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - C₃H₈ (100 MOL C BASIS), STEAM/C RATIO, 2.0

ELEMENTAL COMPOSITION				EQUILIBRIUM PRODUCT COMPOSITIONS											
COMPOSITIONS	H(ATOMS)	O(ATOMS)	N ₂ (MOLS)	RT			H ₂ O	CO ₂	CH ₄	CO	H ₂	N ₂	TOTAL	MOL	MOL
10 ⁻⁴ C	6.66.67	20.00	0.	MOL	MOL	MOL	MOL PC	MOL	MOL PC	MOL	MOL PC	MOL	MOL	MOL	MOL PC
1.0000	400.0	7.9414E-12	2.0711E 02	4.0007E 09	4.6519E 09	165.67	17.16	82.84	0.00	1.99	0.	267.66			
						61.897	6.412	30.948	0.000	0.743	0.	100.00			
1.0000	600.0	2.1990E-07	3.1479E 01	1.0438E 06	1.4885E 06	159.17	20.39	79.55	0.06	15.06	0.	274.23			
						58.042	7.634	29.010	0.022	5.492	0.	100.00			
1.0000	800.0	2.6585E-04	9.0223E 00	3.7690E 03	5.1304E 03	139.55	29.57	69.13	1.30	55.53	0.	295.08			
						47.293	10.021	23.426	0.442	18.818	0.	100.00			
1.0000	1000.0	4.9018E-02	3.7523E 00	6.4774E 01	8.1476E 01	107.73	39.72	47.44	12.84	130.73	0.	338.45			
						31.829	11.734	14.017	3.795	38.625	0.	100.00			
1.0000	1200.0	2.6875E 00	1.9714E 00	3.0042E 00	5.8114E 00	80.30	35.18	15.47	49.35	222.09	0.	402.39			
						19.955	8.742	3.845	12.265	55.194	0.	100.00			
1.0000	1400.0	6.3697E 01	1.2081E 00	2.7306E-01	2.1146E 00	75.41	25.95	1.36	72.69	255.21	0.	430.62			
						17.511	6.026	0.315	16.881	59.266	0.	100.00			
1.0000	1600.0	8.2139E 02	8.2439E-01	4.0069E-02	1.4120E 00	79.57	20.53	0.11	79.36	253.55	0.	433.12			
						18.372	4.741	0.024	18.323	58.540	0.	100.00			
1.0000	1800.0	6.7984E 03	6.0833E-01	8.3445E-03	1.0542E 00	83.19	16.83	0.01	83.16	250.12	0.	433.31			
						19.198	3.883	0.003	19.192	57.724	0.	100.00			
1.0000	2000.0	4.0014E 04	4.7516E-01	2.2622E-03	8.3203E-01	85.85	14.15	0.00	85.85	247.48	0.	433.33			
						19.812	3.266	0.000	19.811	57.111	0.	100.00			
1.0000	2200.0	1.8036E 05	3.8864E-01	7.5373E-04	6.8590E-01	87.80	12.20	0.00	87.80	245.54	0.	433.33			
						20.261	2.816	0.000	20.261	56.662	0.	100.00			
2.0000	400.0	7.9414E-12	2.0711E 02	4.0007E 09	4.6431E 09	165.96	17.02	82.98	0.00	1.41	0.	267.37			
						62.072	6.365	31.036	0.000	0.527	0.	100.00			
2.0000	600.0	2.1990E-07	3.1479E 01	1.0438E 06	1.5377E 06	161.26	19.35	80.61	0.04	10.85	0.	272.12			
						59.262	7.111	29.623	0.015	3.989	0.	100.00			
2.0000	800.0	2.6585E-04	9.0223E 00	3.7690E 03	5.5515E 03	146.39	26.39	72.78	0.83	41.39	0.	287.78			
						50.868	9.171	25.290	0.287	14.382	0.	100.00			
2.0000	1000.0	4.9018E-02	3.7523E 00	6.4774E 01	8.7810E 01	119.95	35.97	55.92	8.11	161.54	0.	321.50			
						37.311	11.187	17.393	2.524	31.585	0.	100.00			
2.0000	1200.0	2.6875E 00	1.9714E 00	3.0042E 00	4.9520E 00	91.65	35.70	27.35	36.94	186.97	0.	378.63			
						24.207	9.429	7.225	9.757	49.382	0.	100.00			
2.0000	1400.0	6.3697E 01	1.2081E 00	2.7306E-01	1.1800E 00	78.13	26.46	4.59	68.96	246.03	0.	424.16			
						18.420	6.237	1.082	16.257	58.004	0.	100.00			
2.0000	1600.0	8.2139E 02	8.2439E-01	4.0069E-02	7.1300E-01	79.84	20.58	0.42	79.00	252.67	0.	432.50			
						18.459	4.758	0.096	18.267	58.420	0.	100.00			
2.0000	1800.0	6.7984E 03	6.0833E-01	8.3445E-03	5.2768E-01	83.22	16.83	0.05	83.12	250.02	0.	433.24			
						19.209	3.885	0.011	19.186	57.709	0.	100.00			
2.0000	2000.0	4.0014E 04	4.7516E-01	2.2622E-03	4.1609E-01	85.86	14.15	0.01	85.84	247.46	0.	433.32			
						19.814	3.266	0.002	19.810	57.109	0.	100.00			
2.0000	2200.0	1.8036E 05	3.8864E-01	7.5373E-04	3.4297E-01	87.80	12.20	0.00	87.80	245.53	0.	433.33			
						20.262	2.816	0.000	20.261	56.661	0.	100.00			
4.0000	400.0	7.9414E-12	2.0711E 02	4.0007E 09	4.6656E 09	166.17	16.92	83.08	0.00	1.00	0.	267.17			
						62.196	6.331	31.098	0.000	0.374	0.	100.00			
4.0000	600.0	2.1990E-07	3.1479E 01	1.0438E 06	1.5760E 06	162.79	18.59	81.38	0.03	7.79	0.	270.57			
						60.164	6.871	30.077	0.010	2.877	0.	100.00			
4.0000	800.0	2.6585E-04	9.0223E 00	3.7690E 03	5.9321E 03	151.67	23.90	75.57	0.53	30.53	0.	282.20			
						53.746	8.469	26.779	0.189	10.818	0.	100.00			
4.0000	1000.0	4.9018E-02	3.7523E 00	6.4774E 01	9.5308E 01	130.46	32.22	62.68	5.10	77.51	0.	307.98			
						42.361	10.461	20.352	1.657	25.169	0.	100.00			
4.0000	1200.0	2.6875E 00	1.9714E 00	3.0042E 00	4.7433E 00	104.34	35.03	39.38	25.59	150.24	0.	354.58			
						29.427	9.881	11.105	7.216	42.371	0.	100.00			

CALIFORNIA RESEARCH
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RE 647655

TABLE F-7B
PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - C₃H₈ (100 MOLE % BASIS), STEAM/C RATIO, 2.0

P(ATM)	T(DEG F)	ELEMENTAL COMPOSITION			RT	EQUILIBRIUM PRODUCT COMPOSITIONS								TOTAL MOLES MOL PC
		C(ATOMS)	H(ATOMS)	O(ATOMS)		H ₂ O MOLES MOL PC	CO ₂ MOLES MOL PC	CH ₄ MOLES MOL PC	CO MOLES MOL PC	H ₂ MOLES MOL PC	N ₂ MOLES MOL PC			
4.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	7.7132E-01	84.62 20.684	27.50 6.722	12.12 2.962	60.38 14.760	224.49 54.873	0. 0.	409.1 100.00		
4.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	3.6989E-01	80.82 18.786	26.75 4.824	1.57 0.365	77.68 18.056	249.33 57.969	0. 0.	430.2 100.00		
4.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	2.6503E-01	83.34 19.250	16.85 3.892	0.19 0.045	82.96 19.161	249.6 57.652	0. 0.	432.95 100.00		
4.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	2.9820E-01	85.88 19.821	14.15 3.267	0.03 0.007	85.81 19.876	247.39 57.099	0. 0.	433.27 100.00		
4.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	1.7151E-01	87.80 20.263	12.20 2.816	0.01 0.002	87.79 20.260	245.52 56.659	0. 0.	433.32 100.00		
6.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	4.6363E 09	166.26 62.252	16.87 6.317	83.13 31.126	0.00 0.000	0.82 0.36	0. 0.	267.28 100.00		
6.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	1.5941E 06	163.48 60.575	18.29 6.762	81.73 30.283	0.02 0.008	6.40 2.371	0. 0.	269.88 100.00		
6.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	6.1318E 03	154.16 55.135	22.71 8.124	76.87 27.493	0.42 0.149	25.44 9.099	0. 0.	279.60 100.00		
6.0000	1000.00	4.9010E-02	3.7523E 00	6.4774E 01	9.9905E 01	135.74 45.023	30.18 10.011	65.92 21.865	3.90 1.292	65.75 21.808	0. 0.	301.49 100.00		
6.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	4.7737E 00	111.64 32.657	34.09 9.973	45.73 13.378	20.17 5.901	130.22 38.092	0. 0.	341.87 100.00		
6.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	6.5716E-01	90.32 22.793	28.21 7.120	18.54 4.677	53.25 13.438	205.94 51.971	0. 0.	396.26 100.00		
6.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	2.6029E-01	82.24 19.268	21.00 4.920	3.24 0.760	75.76 17.748	244.61 57.395	0. 0.	426.85 100.00		
6.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	1.7799E-01	83.55 19.319	16.88 3.904	0.43 0.100	82.69 19.119	248.92 57.558	0. 0.	432.47 100.00		
6.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	1.3897E-01	85.91 19.833	14.16 3.269	0.07 0.017	85.77 19.799	247.28 57.783	0. 0.	433.19 100.00		
6.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	1.1437E-01	87.81 20.266	12.20 2.816	0.02 0.004	87.78 20.259	245.52 56.656	0. 0.	433.30 100.00		
12.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	4.6303E 09	166.38 62.324	16.81 6.297	83.19 31.162	0.03 0.000	0.58 0.216	0. 0.	266.96 100.00		
12.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	1.6187E 06	164.39 61.122	17.80 6.616	82.19 30.558	0.02 0.006	4.56 1.697	0. 0.	268.96 100.00		
12.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	6.4303E 03	157.55 57.070	21.09 7.639	78.64 28.485	0.27 0.099	18.51 6.776	0. 0.	276.06 100.00		
12.0000	1000.00	4.9010E-02	3.7523E 00	6.4774E 01	1.6772E 02	143.33 49.006	27.10 9.264	70.43 24.080	2.48 0.847	49.15 16.804	0. 0.	292.48 100.00		
12.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	4.9676E 00	123.15 38.088	31.85 9.852	55.00 17.011	13.14 4.065	100.18 30.984	0. 0.	323.33 100.00		
12.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	5.6500E-01	102.01 27.482	29.05 7.826	31.07 8.369	39.88 10.744	169.19 45.579	0. 0.	371.26 100.00		
12.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	1.5966E-01	87.53 21.112	21.85 5.271	9.38 2.263	68.77 16.587	227.05 54.767	0. 0.	414.58 100.00		
12.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	9.2368E-02	84.58 19.667	17.05 3.963	1.63 0.379	81.33 18.910	245.49 57.081	0. 0.	431.18 100.00		
12.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	6.9936E-02	86.10 19.896	14.19 3.278	0.29 0.066	85.53 19.763	246.66 56.997	0. 0.	432.76 100.00		
12.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	3.7265E-02	87.85 20.280	12.21 2.818	0.06 0.014	87.73 20.251	245.36 56.637	0. 0.	433.21 100.00		

CALIFORNIA RESEARCH
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RE 647656

TABLE F-8A

PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA -

STEAM REFORMER FEED - C₃H₈ (100 MOL % BASIS), STEAM/C RATIO, 3.0

P(ATM)	T(DEG F)	CONDITIONS AND EQUILIBRIUM CONSTANTS				EQUILIBRIUM PRODUCT COMPOSITIONS								TOTAL MOLS MOL PC
		KR	KS	KC	KF	H ₂ O MOLS MOL PC	CO ₂ MOLS MOL PC	CH ₄ MOLS MOL PC	CO MOLS MOL PC	H ₂ MOLS MOL PC	N ₂ MOLS MOL PC			
1.0000	400.0	7.9414E-12	2.0711E-02	4.0007E-09	7.3333E-09	265.20 72.038	17.40 4.726	82.66 22.437	0.00 0.000	2.94 0.798	0. 0.	368.14 100.00		
1.0000	600.0	2.1990E-07	3.1479E-01	1.0438E-06	2.3230E-06	255.78 67.734	22.08 5.848	77.86 20.618	0.06 0.016	21.84 5.785	0. 0.	377.62 100.00		
1.0000	800.0	2.6585E-04	9.0223E-03	3.7690E-03	8.0279E-03	228.28 56.172	35.19 8.660	63.47 15.618	1.33 0.328	78.11 19.221	0. 0.	406.39 100.00		
1.0000	1000.0	4.9018E-02	3.7523E-00	6.4774E-01	1.4165E-02	185.26 40.189	50.94 11.050	36.19 7.851	12.87 2.793	175.70 38.116	0. 0.	460.95 100.00		
1.0000	1200.0	2.6875E-00	1.9714E-00	3.0042E-03	1.4231E-01	156.58 30.134	50.29 9.678	6.86 1.321	42.85 8.247	263.03 50.621	0. 0.	519.61 100.00		
1.0000	1400.0	6.3697E-01	1.2081E-00	2.7306E-01	6.4171E-00	159.26 29.908	41.15 7.728	0.41 0.078	58.44 10.974	273.24 51.312	0. 0.	532.51 100.00		
1.0000	1600.0	8.2139E-02	8.2439E-01	4.0069E-02	4.1379E-04	166.15 31.156	33.88 6.354	0.03 0.006	66.08 12.392	267.12 50.091	0. 0.	533.27 100.00		
1.0000	1800.0	6.7984E-03	6.0833E-01	8.3445E-03	2.9724E-00	171.51 32.159	28.49 5.343	0.00 0.001	71.50 13.407	261.82 49.091	0. 0.	533.33 100.00		
1.0000	2000.0	4.0014E-04	4.7516E-01	2.2622E-03	2.2843E-00	175.55 32.916	24.45 4.584	0.00 0.000	75.55 14.166	257.78 48.334	0. 0.	533.33 100.00		
1.0000	2200.0	1.8036E-05	3.8864E-01	7.5373E-04	1.8490E-00	178.59 33.485	21.41 4.015	0.00 0.000	78.59 14.735	254.75 47.765	0. 0.	533.33 100.00		
2.0000	400.0	7.9414E-12	2.0711E-02	4.0007E-09	7.4626E-09	265.63 72.238	17.19 4.674	82.81 22.521	0.00 0.000	2.09 0.567	0. 0.	367.71 100.00		
2.0000	600.0	2.1990E-07	3.1479E-01	1.0438E-06	2.4104E-06	258.78 69.081	20.59 5.497	79.37 21.187	0.04 0.011	15.82 4.224	0. 0.	374.60 100.00		
2.0000	800.0	2.6585E-04	9.0223E-00	3.7690E-03	8.6185E-03	237.74 59.969	30.71 7.747	68.45 17.266	0.84 0.212	58.70 14.807	0. 0.	396.44 100.00		
2.0000	1000.0	4.9018E-02	3.7523E-00	6.4774E-01	1.4420E-02	201.36 45.736	45.17 10.259	46.53 10.569	8.30 1.886	138.91 31.551	0. 0.	440.27 100.00		
2.0000	1200.0	2.6875E-00	1.9714E-00	3.0042E-00	1.0065E-01	166.92 33.292	49.06 9.786	15.98 3.187	34.96 6.972	234.46 46.763	0. 0.	501.37 100.00		
2.0000	1400.0	6.3697E-01	1.2081E-00	2.7306E-01	3.3246E-00	160.42 30.256	41.15 7.761	1.57 0.295	57.28 10.804	269.79 50.884	0. 0.	530.20 100.00		
2.0000	1600.0	8.2139E-02	8.2439E-01	4.0069E-02	2.0747E-02	166.24 31.185	33.89 6.357	0.13 0.024	65.98 12.378	266.84 50.056	0. 0.	533.08 100.00		
2.0000	1800.0	6.7984E-03	6.0833E-01	8.3445E-03	1.4867E-03	171.52 32.162	28.49 5.343	0.02 0.003	71.49 13.405	261.78 49.087	0. 0.	533.30 100.00		
2.0000	2000.0	4.0014E-04	4.7516E-01	2.2622E-03	1.1422E-00	175.55 32.917	24.45 4.584	0.00 0.000	75.55 14.166	257.78 48.333	0. 0.	533.33 100.00		
2.0000	2200.0	1.8036E-05	3.8864E-01	7.5373E-04	9.2451E-01	178.59 33.485	21.41 4.015	0.00 0.000	78.59 14.735	254.75 47.765	0. 0.	533.33 100.00		
4.0000	400.0	7.9414E-12	2.0711E-02	4.0007E-09	7.4673E-09	265.93 72.380	17.04 4.637	82.96 22.581	0.00 0.000	1.48 0.412	0. 0.	367.41 100.00		
4.0000	600.0	2.1990E-07	3.1479E-01	1.0438E-06	2.4811E-06	260.98 70.085	19.50 5.235	80.48 21.612	0.03 0.007	11.40 3.060	0. 0.	372.38 100.00		
4.0000	800.0	2.6585E-04	9.0223E-00	3.7690E-03	9.1928E-03	245.12 63.054	27.17 6.989	72.29 18.596	0.54 0.138	43.63 11.222	0. 0.	388.75 100.00		
4.0000	1000.0	4.9018E-02	3.7523E-00	6.4774E-01	1.5146E-02	215.58 50.963	39.58 9.357	55.16 13.040	5.26 1.243	107.43 25.397	0. 0.	423.01 100.00		
4.0000	1200.0	2.6875E-00	1.9714E-00	3.0042E-00	8.4990E-06	181.30 37.958	46.56 9.749	27.86 5.833	25.58 5.355	196.32 41.154	0. 0.	477.62 100.00		

CALIFORNIA RESEARCH
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RE 647657

TABLE F-8B

PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - C₃H₈ (100 MOLE-% BASIS), STEAM/C RATIO, 3.0

P(ATOMS)	ELEMENTAL COMPOSITION			RT	EQUILIBRIUM PRODUCT COMPOSITIONS						TOTAL MOLES	
	C(ATOMS)	H(ATOMS)	O(ATOMS)		N2(MOLS)	H2O MOLS	CO2 MOLS	CH4 MOLS	CO MOLS	H2 MOLS	N2 MOLS	MOL PC
100.00	866.67	300.00	0.									
	CONDITIONS AND EQUILIBRIUM CONSTANTS	KR	KS	KC								
	P(ATM)	T(DEG F)				H2O MOLS MOL PC	CO2 MOLS MOL PC	CH4 MOLS MOL PC	CO MOLS MOL PC	H2 MOLS MOL PC	N2 MOLS MOL PC	
4.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	1.8656E 00	164.10 31.381	41.11 7.863	5.21 0.996	53.68 10.265	258.82 49.496	0. 0.	522.92 100.00
4.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	1.0488E 01	166.60 31.298	33.90 6.369	0.51 0.095	65.59 12.321	265.71 49.916	0. 0.	532.32 100.00
4.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	7.4429E-01	171.56 32.176	28.50 5.344	0.06 0.012	71.44 13.398	261.65 49.070	0. 0.	533.21 100.00
4.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	5.7122E-01	175.56 32.919	24.45 4.584	0.01 0.002	75.54 14.165	257.75 48.330	0. 0.	533.31 100.00
4.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	4.6228E-01	178.59 33.486	21.41 4.015	0.00 0.003	78.59 14.735	254.74 47.764	0. 0.	533.33 100.00
6.0000	400.00	7.9414E-12	2.0711E 02	4.0007E-09	7.6319E-09	266.06 72.443	16.97 4.620	83.03 22.608	0.00 0.000	1.21 0.129	0. 0.	367.27 100.00
6.0000	600.00	2.1990E-07	3.1479E 01	1.0438E-06	2.5151E-06	261.99 70.545	19.00 5.115	80.98 21.806	0.02 0.006	9.39 2.527	0. 0.	371.37 100.00
6.0000	800.00	2.6585E-04	9.0223E-00	3.7690E-03	9.5095E-03	248.62 64.555	25.48 6.617	74.10 19.241	0.41 0.198	36.51 9.479	0. 0.	385.13 100.00
6.0000	1000.00	4.9018E-02	3.7523E-00	6.4774E-01	1.5691E-02	222.81 53.751	36.59 8.826	59.40 14.330	4.01 0.968	91.72 22.126	0. 0.	414.53 100.00
6.0000	1200.00	2.6875E-00	1.9714E-00	3.0042E-00	8.1512E-01	190.38 41.074	44.54 9.609	34.92 7.533	20.55 4.433	173.13 37.352	0. 0.	463.50 100.00
6.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	1.4283E 00	168.38 32.723	41.00 7.968	9.38 1.824	49.62 9.642	246.18 47.843	0. 0.	514.57 100.00
6.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	7.1154E-01	167.18 31.478	33.93 6.388	1.11 0.209	64.96 12.232	263.93 49.694	0. 0.	531.11 100.00
6.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	4.9725E-01	171.64 32.199	28.50 5.347	0.14 0.026	71.36 13.387	261.42 49.042	0. 0.	533.06 100.00
6.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	3.8095E-01	175.57 32.923	24.45 4.585	0.02 0.004	75.53 14.163	257.71 48.325	0. 0.	533.29 100.00
6.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	3.0821E-01	178.59 33.487	21.41 4.015	0.01 0.001	78.58 14.735	254.73 47.763	0. 0.	533.32 100.00
12.0000	400.00	7.9414E-12	2.0711E 02	4.0007E-09	7.6742E-09	266.24 72.526	16.88 4.598	83.12 22.642	0.00 0.000	0.86 0.233	0. 0.	367.10 100.00
12.0000	600.00	2.1990E-07	3.1479E 01	1.0438E-06	2.5634E-06	263.32 71.161	18.33 4.955	81.65 22.066	0.01 0.004	6.71 1.815	0. 0.	370.03 100.00
12.0000	800.00	2.6585E-04	9.0223E-00	3.7690E-03	1.0004E-04	253.43 66.662	23.15 6.089	76.58 20.143	0.27 0.071	26.74 7.035	0. 0.	380.17 100.00
12.0000	1000.00	4.9018E-02	3.7523E-00	6.4774E-01	1.6726E-02	233.32 57.960	32.07 7.967	65.39 16.244	2.54 0.630	69.23 17.198	0. 0.	402.55 100.00
12.0000	1200.00	2.6875E-00	1.9714E-00	3.0042E-00	8.0452E-01	205.42 46.525	40.49 9.170	45.91 10.397	13.61 3.082	136.11 30.826	0. 0.	441.52 100.000
12.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	1.0528E-01	179.68 36.423	40.32 8.173	20.00 4.055	39.68 8.043	213.64 43.307	0. 0.	493.33 100.00
12.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	3.8620E-01	169.87 32.320	34.01 6.472	3.88 0.738	62.11 11.817	255.71 48.653	0. 0.	525.58 100.00
12.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	2.5145E-01	172.02 32.319	28.52 5.359	0.54 0.102	70.93 13.327	260.23 48.892	0. 0.	532.25 100.00
12.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	1.9083E-01	175.64 32.944	24.45 4.587	0.09 0.017	75.45 14.152	257.51 48.300	0. 0.	533.15 100.00
12.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	1.5417E-01	178.61 33.491	21.41 4.015	0.02 0.004	78.57 14.732	254.69 47.757	0. 0.	533.29 100.00

CALIFORNIA RESEARCH
CORPORATION
RICHMOND, CALIFORNIA

RE 647658

TABLE F-9A

PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - C₃H₈ (100 MOLE % BASIS), STEAM/C RATIO, 4.0

P(ATM)	T(DEG F)	ELEMENTAL COMPOSITION			RT	EQUILIBRIUM PRODUCT COMPOSITIONS								TOTAL MOLES MOLE PC
		C(MOLE%)	H(ATOMS)	O(ATOMS)		H2O MOLES MOLE PC	CO2 MOLES MOLE PC	CH4 MOLES MOLE PC	CO MOLES MOLE PC	H2 MOLES MOLE PC	N2 MOLES MOLE PC			
1.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	1.0109E-1	364.73 77.834	17.63 3.763	82.37 17.577	0.00 0.000	3.87 0.826	0. 0.	468.60 100.00		
1.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	3.1238E-06	352.55 73.320	23.69 4.927	76.25 15.857	0.06 0.013	28.29 5.883	0. 0.	480.84 100.00		
1.0000	800.00	2.6585E-04	9.0223E-03	3.7690E-03	1.0909E-04	318.13 61.583	40.24 7.791	58.37 11.300	1.38 0.267	98.46 19.059	0. 0.	516.59 100.00		
1.0000	1000.00	4.9018E-02	3.7523E-00	6.4774E-01	2.1673E-02	267.26 46.179	60.06 10.374	27.30 4.717	12.66 2.188	211.49 36.542	0. 0.	578.74 100.00		
1.0000	1200.00	2.6875E-00	1.9714E-00	3.0042E-00	2.9221E-01	242.55 38.693	60.68 9.680	3.24 0.516	36.08 5.756	284.31 45.354	0. 0.	626.86 100.00		
1.0000	1400.00	6.3697E-01	1.2081E-00	2.7306E-01	1.3809E-01	248.85 39.314	51.32 8.108	6.18 0.028	48.50 7.662	284.13 44.888	0. 0.	632.98 100.00		
1.0000	1600.00	8.2139E-02	8.2439E-01	4.0069E-02	8.5514E-00	256.68 40.530	43.33 6.843	0.01 0.002	56.65 8.945	276.63 43.680	0. 0.	633.31 100.00		
1.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	5.9574E-00	262.85 41.503	37.15 5.866	0.00 0.000	62.85 9.923	270.48 42.708	0. 0.	633.33 100.00		
1.0000	2000.00	4.0014E-06	4.7516E-01	2.2622E-03	4.4819E-03	267.63 42.258	32.37 5.111	0.00 0.003	67.63 10.679	265.71 41.953	0. 0.	633.33 100.00		
1.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	3.5741E-00	271.31 42.838	28.69 4.531	0.00 0.000	71.31 11.259	262.03 41.373	0. 0.	633.33 100.00		
2.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	1.0128E-10	365.29 78.047	17.35 3.708	82.65 17.658	0.00 0.000	2.75 0.588	0. 0.	468.04 100.00		
2.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	3.2528E-06	356.40 74.719	21.78 4.567	78.18 16.390	0.04 0.008	20.56 4.315	0. 0.	476.98 100.00		
2.0000	800.00	2.6585E-04	9.0223E-00	3.7690E-03	1.1598E-04	329.83 65.394	34.65 6.810	64.48 12.784	0.87 0.172	74.55 14.780	0. 0.	504.37 100.00		
2.0000	1000.00	4.9018E-02	3.7523E-00	6.4774E-01	2.0737E-02	285.62 51.358	52.97 9.525	38.60 6.940	8.43 1.515	170.51 30.660	0. 0.	556.14 100.00		
2.0000	1200.00	2.6875E-00	1.9714E-00	3.0042E-00	1.8077E-01	250.18 40.691	59.06 9.606	9.25 1.504	31.69 5.155	264.66 43.045	0. 0.	614.84 100.00		
2.0000	1400.00	6.3697E-01	1.2081E-00	2.7306E-01	7.0124E-01	249.43 39.468	51.26 8.111	0.68 0.108	48.06 7.605	282.54 44.708	0. 0.	631.97 100.00		
2.0000	1600.00	8.2139E-02	8.2439E-01	4.0069E-02	4.2809E-01	256.72 40.543	43.33 6.843	0.06 0.009	56.61 8.940	276.50 43.665	0. 0.	633.22 100.00		
2.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	2.9791E-01	262.85 41.504	37.15 5.866	0.01 0.001	62.84 9.922	270.47 42.708	0. 0.	633.32 100.00		
2.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	2.2410E-03	267.63 42.258	32.37 5.111	0.00 0.000	67.63 10.678	265.73 41.953	0. 0.	633.33 100.00		
2.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	1.7871E-02	271.31 42.838	28.69 4.531	0.00 0.000	71.31 11.259	262.03 41.373	0. 0.	633.33 100.00		
4.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	1.0242E-10	365.69 78.199	17.15 3.668	82.85 17.716	0.09 0.000	1.95 0.417	0. 0.	467.64 100.00		
4.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	3.3596E-06	359.24 75.769	20.37 4.296	79.61 16.790	0.03 0.006	14.88 3.139	0. 0.	474.12 100.00		
4.0000	800.00	2.6585E-04	9.0223E-00	3.7690E-03	1.2323E-04	339.06 68.519	30.25 6.103	69.25 13.995	0.55 0.111	55.78 11.272	0. 0.	494.83 100.00		
4.0000	1000.00	4.9018E-02	3.7523E-00	6.4774E-01	2.1010E-02	302.54 56.422	46.02 8.582	48.56 9.056	5.42 1.011	133.67 24.928	0. 0.	536.21 100.00		
4.0000	1200.00	2.6875E-00	1.9714E-00	3.0042E-00	1.3515E-01	263.67 44.356	55.78 9.384	19.45 3.272	24.77 4.166	230.77 38.822	0. 0.	594.44 100.00		

CALIFORNIA RESEARCH
CORPORATION
RICHMOND, CALIFORNIA

RE 647659

TABLE F-9B

PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - C3H8 (100 MOLE % BASIS), STEAM/C RATIO, 4.0

P(ATM)	T(DEG F)	ELEMENTAL COMPOSITION			RT	EQUILIBRIUM PRODUCT COMPOSITIONS						TOTAL MOLES MOL PC
		C(ATOMS)	H(ATOMS)	O(ATOMS)		H2O MOLES MOL PC	CO2 MOLES MOL PC	CH4 MOLES MOL PC	CO MOLES MOL PC	H2 MOLES MOL PC	N2 MOLES MOL PC	
4.0000	1400.00	6.3697E-01	1.2081E-00	2.7306E-01	3.7081E-00	251.48 40.023	51.02 8.119	2.50 0.397	46.49 7.399	276.86 44.062	0. 0.	628.34 100.00
4.0000	1600.00	8.2139E-02	8.2439E-01	4.0069E-02	2.1508E-00	256.90 40.592	43.32 6.845	0.22 0.035	56.45 8.920	275.98 43.607	0. 0.	632.89 100.00
4.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	1.4904E-00	262.88 41.510	37.15 5.867	0.03 0.004	62.82 9.920	270.40 42.699	0. 0.	633.28 100.00
4.0.00	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	1.1206E-00	267.64 42.259	32.37 5.111	0.00 0.001	67.63 10.678	265.69 41.951	0. 0.	633.33 100.00
4.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	8.9355E-01	271.31 42.838	28.69 4.531	0.00 0.000	71.31 11.259	262.03 41.373	0. 0.	633.33 100.00
6.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	1.0102E-10	365.87 78.267	17.07 3.651	82.93 17.741	0.00 0.000	1.60 0.342	0. 0.	467.47 100.00
6.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	3.4126E-06	360.54 76.253	19.72 4.171	80.26 16.974	0.02 0.005	12.28 2.597	0. 0.	472.82 100.00
6.0000	800.00	2.6585E-04	9.0223E-00	3.7690E-03	1.3426E-04	343.46 70.050	28.06 5.723	71.52 14.586	0.42 0.087	46.85 9.554	0. 0.	484.31 100.00
6.0000	1000.00	4.9018E-02	3.7523E-03	6.4774E-01	2.1478E-02	311.33 59.171	42.26 8.031	53.59 10.185	4.15 0.789	114.83 21.824	0. 0.	526.16 100.00
6.0000	1200.00	2.6875E-00	1.9714E-00	3.0042E-00	1.2313E-01	273.29 47.081	53.14 9.154	26.43 4.553	20.43 3.520	207.18 35.691	0. 0.	580.47 100.00
6.0000	1400.00	6.3697E-01	1.2081E-00	2.7306E-01	2.6720E-00	254.29 40.788	50.66 8.127	4.95 0.794	44.39 7.120	269.15 43.172	0. 0.	623.44 100.00
6.0000	1600.00	8.2139E-02	8.2439E-01	4.0069E-02	1.4452E-00	257.19 40.674	43.31 6.848	0.50 0.079	56.23 8.887	275.14 43.512	0. 0.	632.34 100.00
6.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	9.9456E-01	262.91 41.520	37.15 5.867	0.06 0.010	62.79 9.916	270.30 42.687	0. 0.	633.21 100.00
6.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	7.4719E-01	267.64 42.261	32.37 5.111	0.01 0.002	67.62 10.677	265.67 41.949	0. 0.	633.31 100.00
6.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	5.9572E-01	271.31 42.838	28.69 4.531	0.00 0.000	71.30 11.259	262.02 41.372	0. 0.	633.33 100.00
12.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	1.0102E-10	366.10 78.355	16.95 3.628	83.05 17.775	0.00 0.000	1.13 0.242	0. 0.	467.23 100.00
12.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	3.4880E-06	362.27 76.902	18.86 4.003	81.13 17.222	0.01 0.003	8.81 1.870	0. 0.	471.08 100.00
12.0000	800.00	2.6585E-04	9.0223E-00	3.7690E-03	1.3426E-04	349.55 72.212	25.09 5.183	74.66 15.419	0.27 0.057	34.51 7.130	0. 0.	484.06 100.00
12.0000	1000.00	4.9018E-02	3.7523E-00	6.4774E-01	2.2576E-02	324.25 63.367	36.56 7.144	60.81 11.884	2.63 0.514	87.45 17.091	0. 0.	511.71 100.00
12.0000	1200.00	2.6875E-00	1.9714E-00	3.0042E-00	1.1463E-01	290.38 52.143	47.85 8.593	38.23 6.865	13.92 2.499	166.50 29.899	0. 0.	556.88 100.00
12.0000	1400.00	6.3697E-01	1.2081E-00	2.7306E-01	1.7437E-00	263.48 43.356	49.34 8.118	12.81 2.198	37.85 6.229	244.23 40.189	0. 0.	607.71 100.00
12.0000	1600.00	8.2139E-02	8.2439E-01	4.0069E-02	7.5188E-01	258.65 41.082	43.22 6.864	1.87 0.297	54.92 8.722	270.95 43.335	0. 0.	629.60 100.00
12.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	8.9981E-01	263.10 41.574	37.15 5.870	0.25 0.039	62.61 9.893	269.74 42.624	0. 0.	632.84 100.00
12.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	3.7391E-01	267.67 42.270	32.37 5.112	0.04 0.007	67.59 10.673	265.58 41.939	0. 0.	633.25 100.00
12.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	2.9792E-01	271.32 42.840	28.69 4.531	0.01 0.011	71.30 11.258	262.02 41.370	0. 0.	633.32 100.00

CALIFORNIA RESEARCH
CORPORATION
RICHMOND, CALIFORNIA

RE 647660

TABLE F-10A

PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - C₃H₈ (100 MOLE % BASIS), STEAM/C RATIO, 5.0

C(ATOMS)	H(ATOMS)	O(ATOMS)	N2(MOLS)	ELEMENTAL COMPOSITION															
				100.00	1266.67	500.00	C	EQUILIBRIUM PRODUCT COMPOSITIONS											
P(ATM)	T(DEG F)	KR	KS	KC	RT	H2O		CO2		CH4		CO		H2		N2		TOTAL	
						MOL	PC	MOL	PC	MOL	PC	MOL	PC	MOL	PC	MOL	PC	MOL	PC
1.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	1.2068E-10	464.27	17.86	82.14	0.00	4.79	0.	0.00	0.842	0.	569.06	0.	100.00		
1.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	3.8982E-06	449.46	25.24	74.70	0.06	34.47	0.	0.011	5.903	0.	583.93	0.	100.00		
1.0000	800.00	2.6585E-04	9.0223E-00	3.7690E-03	1.3843E-04	408.83	44.87	53.70	1.42	117.09	0.	0.228	18.707	0.	625.93	0.	100.00		
1.0000	1000.00	4.9018E-02	3.7523E-00	6.4774E-01	3.1290E-02	352.85	67.46	20.32	12.22	239.85	0.	0.939	9.739	2.933	1.764	34.625	0.	692.70	
1.0000	1200.00	2.6875E-00	1.9714E-02	3.0042E-00	5.3148E-01	333.84	67.82	1.66	30.52	296.18	0.	0.227	4.181	40.572	0.	730.02	0.	100.00	
1.0000	1400.00	6.3697E-01	1.2081E-00	2.7306E-01	2.5076E-01	341.55	58.54	0.09	41.37	291.61	0.	0.012	5.643	39.775	0.	733.16	0.	100.00	
1.0000	1600.00	8.2139E-02	8.2439E-01	4.0069E-02	1.5026E-01	349.62	50.39	0.01	49.69	283.70	0.	0.001	6.764	38.688	0.	733.32	0.	100.00	
1.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	1.0211E-01	356.13	43.87	0.00	56.13	277.20	0.	0.000	7.654	37.800	0.	733.33	0.	100.00	
1.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	7.5690E-06	361.31	38.69	0.00	61.31	272.03	0.	0.000	8.360	37.094	0.	733.33	0.	100.00	
1.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	5.9450E-00	365.36	34.64	0.00	65.36	267.97	0.	0.000	8.913	36.541	0.	733.33	0.	100.00	
2.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	1.2877E-10	464.96	17.52	82.48	0.00	3.41	0.	0.000	0.600	0.	568.37	0.	100.00		
2.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	4.0684E-06	454.10	22.93	77.03	0.04	25.18	0.	0.007	4.347	0.	579.28	0.	100.00		
2.0000	800.00	2.6585E-04	9.0223E-00	3.7690E-03	1.4550E-04	422.47	38.31	60.79	0.90	89.29	0.	0.147	14.595	0.	611.76	0.	100.00		
2.0000	1000.00	4.9018E-02	3.7523E-00	6.4774E-01	2.8018E-02	372.13	59.71	31.84	8.45	197.53	0.	0.000	8.917	4.754	1.261	29.498	0.	669.66	
2.0000	1200.00	2.6875E-00	1.9714E-00	3.0042E-00	3.0215E-01	338.99	66.42	5.40	28.18	283.54	0.	0.748	3.900	39.243	0.	722.53	0.	100.00	
2.0000	1400.00	6.3697E-01	1.2081E-00	2.7306E-01	1.2638E-01	341.86	58.48	0.35	41.17	290.78	0.	0.047	5.620	39.689	0.	732.64	0.	100.00	
2.0000	1600.00	8.2139E-02	8.2439E-01	4.0069E-02	7.5145E-03	349.64	50.39	0.03	49.58	283.64	0.	0.004	6.762	38.681	0.	733.28	0.	100.00	
2.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	5.1057E-00	356.14	43.87	0.00	56.13	277.19	0.	0.001	7.654	37.799	0.	733.33	0.	100.00	
2.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	3.7745E-06	361.31	38.69	0.00	61.31	272.02	0.	0.000	8.360	37.094	0.	733.33	0.	100.00	
2.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	2.9725E-00	365.36	34.64	0.00	65.36	267.97	0.	0.000	8.913	36.541	0.	733.33	0.	100.00	
4.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	1.2966E-10	465.46	17.27	82.73	0.00	2.42	0.	0.000	0.426	0.	567.88	0.	100.00		
4.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	4.2140E-06	457.54	21.21	78.76	0.03	18.27	0.	0.005	3.173	0.	575.82	0.	100.00		
4.0000	800.00	2.6585E-04	9.0223E-00	3.7690E-03	1.5378E-04	433.35	33.04	66.39	0.57	67.21	0.	0.095	11.191	0.	600.55	0.	100.00		
4.0000	1000.00	4.9018E-02	3.7523E-00	6.4774E-01	2.7300E-02	390.92	51.77	42.69	5.54	157.04	0.	0.855	24.236	0.	647.96	0.	100.00		
4.0000	1200.00	2.6875E-00	1.9714E-00	3.0042E-00	2.0315E-01	350.27	63.15	13.42	23.43	256.22	0.	3.317	36.267	0.	706.49	0.	100.00		

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TABLE F-10B
PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - C3H8 (100 MOLE % BASIS), STEAM/C RATIO, 5.0

P(ATM)	T(DEG F)	K _R	K _S	K _C	RT	EQUILIBRIUM PRODUCT COMPOSITIONS								TOTAL MOLES MOLE PC
						H ₂ O MOLES MOLE PC	CO ₂ MOLES MOLE PC	CH ₄ MOLES MOLE PC	CO MOLES MOLE PC	H ₂ MOLES MOLE PC	N ₂ MOLES MOLE PC			
4.0000	1400.00	6.3697E 01	1.2081E 03	2.7306E-01	6.5114E 06	343.07 46.950	58.25 7.972	1.32 0.181	40.43 5.533	287.63 39.364	0. 0.	733.31 100.00		
4.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	3.7668E 06	349.74 47.707	50.38 6.872	0.12 0.016	49.51 6.753	283.36 38.672	0. 0.	733.31 100.00		
4.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	2.5536E 06	356.15 48.567	43.87 5.982	0.01 0.002	56.12 7.653	277.16 37.796	0. 0.	733.31 100.00		
4.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	1.8874E 06	361.31 49.270	38.69 5.276	0.00 0.000	61.31 8.360	272.02 37.094	0. 0.	733.31 100.00		
4.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	1.4863E 06	365.36 49.822	34.64 4.723	0.00 0.000	65.36 8.913	267.97 36.541	0. 0.	733.31 100.00		
6.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	1.2900E 11	465.68 82.035	17.16 3.023	82.84 14.593	0.00 0.000	1.98 0.349	0. 0.	567.66 100.00		
6.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	4.2884E 06	459.13 79.955	20.43 3.557	79.55 13.854	0.32 0.004	15.10 2.630	0. 0.	574.23 100.00		
6.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	1.5883E 04	438.57 73.685	30.50 5.124	69.07 11.604	0.44 0.073	56.63 9.514	0. 0.	595.29 100.00		
6.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	2.7502E 02	400.94 62.973	47.39 7.444	48.33 7.591	4.28 0.672	135.74 21.320	0. 0.	636.68 100.00		
6.0000	1200.00	2.6875E 00	1.9714E 03	3.0042E 06	1.7569E 01	359.53 51.826	60.28 8.689	19.81 2.855	19.92 2.871	234.19 33.759	0. 0.	693.72 100.00		
6.0000	1400.00	6.3697E 01	1.2081E 03	2.7306E-01	4.5437E 00	344.85 47.381	57.91 7.957	2.76 0.379	39.33 5.404	282.97 38.880	0. 0.	727.82 100.00		
6.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	2.5217E 00	349.91 47.748	50.35 6.871	0.26 0.036	49.38 6.739	282.91 38.676	0. 0.	732.81 100.00		
6.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	1.7033E 00	356.17 48.573	43.87 5.982	0.03 0.005	56.19 7.651	277.10 37.790	0. 0.	733.27 100.00		
6.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	1.2584E 00	361.31 49.271	38.69 5.276	0.01 0.001	61.30 8.360	272.01 37.093	0. 0.	733.32 100.00		
6.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	9.9087E-01	365.37 49.823	34.64 4.723	0.00 0.000	65.36 8.913	267.97 36.541	0. 0.	733.33 100.00		
12.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	1.3087E 10	465.97 82.127	17.02 2.999	82.98 14.626	0.00 0.000	1.43 0.248	0. 0.	567.37 100.00		
12.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	4.3951E 06	461.24 80.622	19.37 3.386	80.61 14.091	0.01 0.003	10.86 1.899	0. 0.	572.11 100.00		
12.0000	800.00	2.6585E-04	9.0223E 03	3.7690E 03	1.6736E 04	445.84 75.853	26.94 4.583	72.78 12.383	0.28 0.048	41.93 7.133	0. 0.	587.77 100.00		
12.0000	1000.00	4.9018E-02	3.7523E 03	6.4774E 01	2.8453E 02	415.90 67.063	40.69 6.562	56.59 9.125	2.72 0.438	104.26 16.812	0. 0.	620.16 100.00		
12.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	1.5367E 01	377.43 56.336	54.27 8.100	31.69 4.731	14.04 2.096	192.52 28.737	0. 0.	669.95 100.00		
12.0000	1400.00	6.3697E 01	1.2081E 03	2.7306E-01	2.7146E 00	351.71 49.061	56.51 7.883	8.22 1.147	35.27 4.919	265.17 36.990	0. 0.	716.89 100.00		
12.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	1.2885E 00	350.76 47.963	50.24 6.870	1.01 0.138	48.75 6.666	280.56 38.364	0. 0.	731.32 100.00		
12.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	8.5398E 01	356.27 48.600	43.86 5.983	0.13 0.018	56.01 7.641	276.80 37.759	0. 0.	733.67 100.00		
12.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	6.2947E 01	361.33 49.276	38.69 5.276	0.02 0.003	61.29 8.358	271.96 37.087	0. 0.	733.29 100.00		
12.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	4.9548E 01	365.37 49.824	34.64 4.723	0.01 0.001	65.36 8.913	267.96 36.540	0. 0.	733.32 100.00		

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TABLE F-11

PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - C₆H₁₄ (100 MOLE % BASIS), STEAM/C RATIO, 1.0

ELEMENTAL COMPOSITION

C(ATOMS)	H(ATOMS)	O(ATOMS)	N ₂ (MOLES)
100.00	433.33	100.00	0.

P(ATM)	T(DEG F)	CONDITIONS AND EQUILIBRIUM CONSTANTS			EQUILIBRIUM PRODUCT COMPOSITIONS						TOTAL MOLES MOLE PC	
		KR	KS	KC	RT	H ₂ O MOLES MOL PC	CO ₂ MOLES MOL PC	CH ₄ MOLES MOL PC	CO MOLES MOL PC	H ₂ MOLES MOL PC	N ₂ MOLES MOL PC	
1.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	3.6053E-02	2.78 0.898	1.06 0.342	3.83 1.240	95.11 30.781	206.23 66.739	0. 0.	309.00 100.00
CONDITIONS LEAD TO CARBON FORMATION.												
1.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	9.5909E-03	1.05 0.325	0.30 0.094	1.35 0.429	98.36 31.327	212.92 67.815	0. 0.	313.97 100.00
1.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	3.1652E-03	0.45 0.143	0.10 0.031	0.55 0.174	99.35 31.484	215.11 68.168	0. 0.	315.56 100.00
1.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	1.2401E-03	0.22 0.069	0.04 0.012	0.26 0.081	99.70 31.537	215.94 68.301	0. 0.	316.15 100.00
2.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	3.6068E-02	5.19 1.715	1.97 0.652	7.16 2.367	90.87 30.056	197.17 65.211	0. 0.	302.35 100.00
CONDITIONS LEAD TO CARBON FORMATION.												
2.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	9.5859E-03	2.05 0.659	0.58 0.185	2.63 0.844	96.80 31.083	209.36 67.229	0. 0.	311.41 100.00
2.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	3.1639E-03	0.89 0.284	0.20 0.062	1.09 0.346	98.71 31.389	213.59 67.918	0. 0.	314.49 100.00
2.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	1.2398E-03	0.43 0.137	0.08 0.025	0.51 0.162	99.41 31.495	215.21 68.182	0. 0.	315.64 100.00
4.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	3.6096E-02	9.18 3.152	3.48 1.196	12.67 4.348	83.85 28.781	182.15 62.523	0. 0.	291.33 100.00
CONDITIONS LEAD TO CARBON FORMATION.												
4.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	9.5763E-03	3.91 1.275	1.10 0.359	5.01 1.634	93.89 30.618	202.74 66.114	0. 0.	306.65 100.00
4.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	3.1614E-03	1.75 0.560	0.38 0.123	2.13 0.683	97.48 31.204	210.65 67.429	0. 0.	312.40 100.00
4.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	1.2392E-03	0.86 0.272	0.15 0.049	1.01 0.321	98.84 31.412	213.79 67.946	0. 0.	314.64 100.00
6.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	3.6122E-02	12.38 4.384	4.69 1.662	17.08 6.045	78.23 27.690	170.12 60.219	0. 0.	282.51 100.00
CONDITIONS LEAD TO CARBON FORMATION.												
6.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	9.5670E-03	5.60 1.853	1.58 0.523	7.18 2.376	91.24 30.181	196.70 65.067	0. 0.	302.30 100.00
6.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	3.1590E-03	2.57 0.829	0.57 0.182	3.14 1.011	96.30 31.024	207.82 66.954	0. 0.	310.39 100.00
6.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	1.2386E-03	1.27 0.406	0.23 0.073	1.50 0.479	98.27 31.330	212.39 67.713	0. 0.	313.66 100.00
12.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	3.6185E-02	19.16 7.263	7.24 2.746	26.41 10.009	66.35 25.146	144.69 54.837	0. 0.	263.85 100.000
CONDITIONS LEAD TO CARBON FORMATION.												
12.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	9.5415E-03	9.90 3.400	2.81 0.963	12.71 4.363	84.49 29.008	181.35 62.266	0. 0.	291.25 100.000
12.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	3.1521E-03	4.86 1.593	1.07 0.352	5.93 1.945	93.00 30.510	199.95 65.599	0. 0.	304.81 100.000
12.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	1.2369E-03	2.47 0.796	0.45 0.143	2.92 0.939	96.63 31.090	208.35 67.032	0. 0.	310.83 100.000

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TABLE F-12A

PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA -

STEAM REFORMER FEED - C6H14 (100 MOL C BASIS), STEAM/C RATIO, 2.0

ELEMENTAL COMPOSITION				EQUILIBRIUM PRODUCT COMPOSITIONS												
C(ATOMS)	H(ATOMS)	O(ATOMS)	N2(MOLS)	CONDITIONS AND EQUILIBRIUM CONSTANTS			RT	H2O MOLS MOL PC	CO2 MOLS MOL PC	CH4 MOLS MOL PC	CO MOLS MOL PC	H2 MOLS MOL PC	N2 MOLS MOL PC	TOTAL MOLS MOL PC		
100.00	633.33	200.00	0.	P(ATM)	T(DEG F)	KR	KS	KC	RT	H2O MOLS MOL PC	CO2 MOLS MOL PC	CH4 MOLS MOL PC	CO MOLS MOL PC	H2 MOLS MOL PC	N2 MOLS MOL PC	TOTAL MOLS MOL PC
1.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	4.0748E 09	157.44	21.28	78.72	0.0	1.78	0.	259.23	100.000			
						60.735	8.209	30.367	0.000	0.688	0.					
1.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	1.3330E 06	151.53	24.20	75.73	0.07	13.68	0.	265.21	100.000			
						57.137	9.125	28.555	0.026	5.157	0.					
1.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	4.7757E 03	133.32	32.64	65.96	1.40	51.41	0.	284.74	100.000			
						46.824	11.463	23.167	0.490	18.056	0.					
1.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	7.8339E 01	103.51	41.66	45.17	13.17	122.82	0.	326.33	100.000			
						31.720	12.766	13.841	4.037	37.636	0.					
1.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	5.7747E 00	78.15	36.25	14.40	49.34	209.71	0.	387.86	100.000			
						20.149	9.347	3.713	12.722	54.068	0.					
1.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	2.1569E 00	74.32	26.90	1.22	71.88	239.90	0.	414.22	100.000			
						17.942	6.495	0.295	17.352	57.916	0.					
1.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	1.4473E 00	78.68	21.41	0.09	78.49	237.79	0.	416.48	100.000			
						18.892	5.141	0.023	18.847	57.097	0.					
1.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	1.0822E 00	82.39	17.62	0.01	82.37	234.25	0.	416.64	100.000			
						19.774	4.230	0.003	19.769	56.224	0.					
1.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	8.5512E-01	85.13	14.87	0.00	85.13	231.53	0.	416.66	100.000			
						20.431	3.569	0.000	20.431	55.568	0.					
1.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	7.0553E-01	87.14	12.86	0.00	87.14	229.52	0.	416.66	100.000			
						20.914	3.086	0.000	20.914	55.086	0.					
2.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	4.0711E 09	157.70	21.15	78.85	0.09	1.26	0.	258.97	100.000			
						60.896	8.167	30.448	0.000	0.488	0.					
2.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	1.3384E 06	153.44	23.25	76.70	0.05	9.82	0.	263.27	100.000			
						58.284	8.833	29.133	0.018	3.732	0.					
2.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	5.1155E 03	139.72	29.69	69.41	0.90	38.12	0.	277.84	100.000			
						50.287	10.686	24.982	0.323	13.722	0.					
2.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	8.3616E 01	115.04	38.27	53.31	8.42	95.01	0.	310.05	100.000			
						37.103	12.343	17.193	2.717	30.644	0.					
2.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	4.8578E 00	88.76	36.98	25.74	37.28	176.42	0.	365.18	100.000			
						24.306	10.126	7.049	10.209	48.311	0.					
2.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	1.1950E 00	76.76	27.40	4.17	68.43	231.56	0.	408.33	100.000			
						18.800	6.712	1.021	16.758	56.710	0.					
2.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	7.3023E-01	78.91	21.46	0.37	78.17	237.01	0.	415.92	100.000			
						18.973	5.159	0.089	18.795	56.984	0.					
2.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	5.4168E-01	82.42	17.63	0.04	82.33	234.16	0.	416.58	100.000			
						19.784	4.231	0.010	19.763	56.211	0.					
2.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	4.2763E-01	85.13	14.87	0.01	85.12	231.52	0.	416.65	100.000			
						20.433	3.570	0.002	20.430	55.566	0.					
2.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	3.5278E-01	87.14	12.86	0.00	87.14	229.52	0.	416.66	100.000			
						20.915	3.086	0.000	20.914	55.085	0.					
4.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	4.0788E 09	157.88	21.06	78.94	0.00	0.90	0.	258.78	100.000			
						61.011	8.137	30.505	0.000	0.346	0.					
4.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	1.3951E 06	154.83	22.57	77.40	0.03	7.03	0.	261.86	100.000			
						59.128	8.618	29.558	0.012	2.684	0.					
4.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	5.4127E 03	144.64	27.39	72.02	0.59	27.98	0.	272.62	100.000			
						53.055	10.046	26.420	0.215	10.264	0.					
4.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	8.9947E 01	124.92	34.86	59.78	5.37	72.19	0.	297.11	100.000			
						42.045	11.731	20.119	1.897	24.297	0.					
4.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	4.5999E 00	100.67	36.62	37.29	26.09	141.41	0.	342.09	100.000			
						29.429	10.704	10.901	7.627	41.339	0.					

CALIFORNIA RESEARCH
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RE 647664

TABLE F-12B
PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - C6H14 (100 MOLE % BASIS), STEAM/C RATIO, 2.0

ELEMENTAL COMPOSITION				EQUILIBRIUM PRODUCT COMPOSITIONS											
C(ATOMS)	H(ATOMS)	D(ATOMS)	N2(MOL%)	CONDITIONS AND EQUILIBRIUM CONSTANTS			RT	H2O MOLS MOL PC	CO2 MOLS MOL PC	CH4 MOLS MOL PC	CO MOLS MOL PC	H2 MOLS MOL PC	N2 MOLS MOL PC	TOTAL MOLS MOL PC	
100.00	633.33	200.00	0.	P(ATM)	T(DEG F)	KR	KS	KC							
4.0000	1400.00	6.3697E-01	1.2081E-00	2.7306E-01	7.7120E-01	82.69 20.970	28.48 7.224	11.17 2.834	60.34 15.303	211.63 53.670	0. 0.	394.32 100.000			
4.0000	1600.00	8.2139E-02	8.2439E-01	4.0069E-02	3.7772E-01	79.78 19.278	21.63 5.226	1.41 0.340	76.97 18.598	234.07 56.559	0. 0.	413.85 100.000			
4.0000	1800.0	6.7984E-03	6.0833E-01	8.3445E-03	2.7195E-01	82.53 19.823	17.65 4.239	0.17 0.042	82.18 19.740	233.79 56.157	0. 0.	416.32 100.000			
4.0000	2000.0	4.0014E-04	4.7516E-01	2.2622E-03	2.1396E-01	85.15 20.440	14.88 3.571	0.03 0.007	85.10 20.426	231.46 55.557	0. 0.	416.61 100.000			
4.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	1.7641E-01	87.15 20.916	12.86 3.086	0.01 0.001	87.13 20.913	229.51 55.083	0. 0.	416.65 100.000			
6.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	4.0827E-09	157.97 61.062	21.02 8.124	78.98 30.531	0.00 0.000	0.74 0.283	0. 0.	258.70 100.000			
6.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	1.4078E-06	155.46 59.511	22.26 8.520	77.72 29.751	0.03 0.010	5.77 2.208	0. 0.	261.23 100.000			
6.0000	800.00	2.6585E-04	9.0223E-00	3.769CE-03	5.5646E-03	146.94 54.382	26.30 9.734	73.24 27.106	0.46 0.171	23.25 8.607	0. 0.	279.19 100.000			
6.0000	1000.0	4.9018E-02	3.7523E-00	6.4774E-01	9.3611E-01	129.87 44.641	33.00 11.342	62.87 21.610	4.13 1.421	61.06 20.987	0. 0.	290.93 100.000			
6.0000	1200.00	2.6875E-00	1.9714E-00	3.0042E-00	4.6000E-00	107.52 32.597	35.88 10.879	43.41 13.159	20.71 6.278	122.33 37.086	0. 0.	329.45 100.000			
6.0000	1400.00	6.3697E-01	1.2081E-00	2.7306E-01	6.5161E-01	87.97 23.017	29.27 7.659	17.24 4.510	53.49 13.996	194.22 50.818	0. 0.	382.19 100.000			
6.0000	1600.00	8.2139E-02	8.2439E-01	4.0069E-02	2.6476E-01	81.05 19.729	21.87 5.324	2.92 0.711	75.21 18.306	229.77 55.929	0. 0.	410.82 100.000			
6.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	1.8252E-01	82.71 19.886	17.68 4.251	0.38 0.092	81.94 19.7e1	233.19 56.069	0. 0.	415.90 100.000			
6.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	1.4280E-01	85.18 20.450	14.88 3.572	0.06 0.015	85.06 20.420	231.35 55.542	0. 0.	416.54 100.000			
6.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	1.1764E-01	87.15 20.918	12.86 3.087	0.01 0.003	87.13 20.912	229.48 55.080	0. 0.	416.64 100.000			
12.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	4.1014E-09	158.07 61.129	20.96 8.107	79.04 30.564	0.09 0.000	0.52 0.20	0. 0.	258.59 100.000			
12.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	1.4243E-06	156.29 60.019	21.85 8.390	78.13 30.006	0.02 0.007	4.11 1.578	0. 0.	260.40 100.000			
12.0000	800.00	2.6585E-04	9.0223E-00	3.769CE-03	5.7862E-03	150.06 56.221	24.81 9.297	74.88 28.053	0.31 0.116	16.85 6.313	0. 0.	266.91 100.000			
12.0000	1000.00	4.9018E-02	3.7523E-00	6.4774E-01	9.9876E-01	136.96 48.505	30.18 10.690	67.15 23.781	2.67 0.944	45.40 16.080	0. 0.	282.37 100.000			
12.0000	1200.00	2.6875E-00	1.9714E-00	3.0042E-00	4.7353E-00	118.31 37.917	34.01 10.901	52.32 16.768	13.67 4.380	93.71 3e.034	0. 0.	312.92 100.000			
12.0000	1400.00	6.3697E-01	1.2081E-00	2.7306E-01	5.5281E-01	98.87 27.597	30.33 8.465	29.20 8.150	40.47 11.297	159.44 44.491	0. 0.	358.27 100.000			
12.0000	1600.00	8.2139E-02	8.2439E-01	4.0069E-02	1.6052E-01	85.83 21.484	22.74 5.693	8.58 2.146	68.68 17.191	213.68 53.486	0. 0.	399.51 100.000			
12.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	9.4428E-02	83.62 20.209	17.84 4.311	1.46 0.352	80.71 19.536	230.14 55.622	0. 0.	413.75 100.000			
12.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	7.1821E-02	85.35 20.509	14.91 3.582	0.25 0.061	84.84 20.386	230.81 55.462	0. 0.	416.16 100.000			
12.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	5.8894E-02	87.19 20.931	12.87 3.088	0.06 0.013	87.08 20.905	229.36 55.062	0. 0.	416.55 100.000			

CALIFORNIA RESEARCH
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RE 647665

TABLE F-13A
PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - C₆H₁₄ (100 MOLE % BASIS), STEAM/C RATIO, 3.0

ELEMENTAL COMPOSITION												
C(ATOMS)	H(ATOMS)	O(ATOMS)	N2(MOLS)									
100.00	833.33	300.00	0.									
CONDITIONS AND EQUILIBRIUM CONSTANTS												
P(ATM)	T(DEG F)	KR	KS	KC	RT	H2O MOLES MOL PC	CO2 MOLES MOL PC	CH4 MOLES MOL PC	CO MOLES MOL PC			
1.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	6.5891E-09	256.99 71.453	21.50 5.978	78.50 21.825	0.00 0.000	2.68 0.744	0. 0.	359.67 100.000
1.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	2.1372E-06	248.27 67.380	25.83 7.011	74.10 20.111	0.07 0.018	20.19 5.480	0. 0.	368.46 100.000
1.0000	800.00	2.6585E-04	9.0223E-00	3.7690E-03	7.6903E-03	222.23 56.141	38.19 9.647	60.41 15.262	1.40 0.354	73.61 18.597	0. 0.	395.84 100.000
1.0000	1000.00	4.9018E-02	3.7523E-00	6.4774E-01	1.4008E-02	181.20 40.404	52.89 11.794	34.09 7.602	13.01 2.902	167.28 37.299	0. 0.	448.48 100.000
1.0000	1200.00	2.6875E-00	1.9714E-00	3.0042E-00	1.4588E-01	154.64 30.669	51.57 10.227	6.21 1.232	42.22 8.373	249.60 49.499	0. 0.	504.24 100.000
1.0000	1400.00	6.3697E-01	1.2081E-00	2.7306E-01	6.6679E-00	157.99 30.623	42.37 8.213	0.37 0.071	57.26 11.098	257.94 49.995	0. 0.	515.93 100.000
1.0000	1600.00	8.2139E-02	8.2439E-01	4.0069E-02	4.3915E-01	164.96 31.931	35.07 6.789	0.03 0.006	64.90 12.563	251.65 48.712	0. 0.	516.61 100.000
1.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	3.0897E-00	170.38 32.978	29.62 5.733	0.00 0.001	70.38 13.622	246.27 47.667	0. 0.	516.66 100.000
1.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	2.3746E-00	174.50 33.774	25.51 4.936	0.00 0.009	74.49 14.418	242.17 46.872	0. 0.	516.66 100.000
1.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	1.9223E-00	177.60 34.374	22.40 4.336	0.00 0.000	77.60 15.019	239.07 46.271	0. 0.	516.66 100.000
2.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	6.6642E-09	257.38 71.638	21.31 5.931	78.69 21.902	0.00 0.000	1.90 0.528	0. 0.	359.28 100.000
2.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	2.2009E-06	251.07 68.666	24.44 6.385	75.51 20.652	0.05 0.012	14.57 3.985	0. 0.	365.64 100.000
2.0000	800.00	2.6585E-04	9.0223E-00	3.7690E-03	8.1736E-03	231.25 59.860	33.93 8.783	65.18 16.871	0.90 0.232	55.06 14.254	0. 0.	386.31 100.000
2.0000	1000.00	4.9018E-02	3.7523E-00	6.4774E-01	1.4116E-02	196.60 45.877	47.45 11.073	44.06 10.281	8.49 1.980	131.94 30.788	0. 0.	428.55 100.000
2.0000	1200.00	2.6875E-00	1.9714E-00	3.0042E-00	1.0169E-01	164.23 33.707	50.50 10.364	14.72 3.022	34.78 7.138	222.99 45.768	0. 0.	487.22 100.000
2.0000	1400.00	6.3697E-01	1.2081E-00	2.7306E-01	3.4444E-00	159.01 30.943	42.38 8.247	1.39 0.271	56.23 10.942	254.87 49.597	0. 0.	513.88 100.000
2.0000	1600.00	8.2139E-02	8.2439E-01	4.0069E-02	2.1562E-00	165.04 31.957	35.08 6.792	0.11 0.022	64.81 12.550	251.40 48.679	0. 0.	516.44 100.000
2.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	1.5453E-00	170.39 32.981	29.62 5.733	0.01 0.003	70.37 13.620	246.24 47.663	0. 0.	516.64 100.000
2.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	1.1873E-00	174.50 33.774	25.51 4.937	0.00 0.000	74.49 14.418	242.16 46.871	0. 0.	516.66 100.000
2.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	9.6110E-01	177.60 34.374	22.40 4.336	0.00 0.000	77.60 15.019	239.07 46.271	0. 0.	516.66 100.000
4.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	6.6616E-09	257.66 71.771	21.17 5.897	78.83 21.958	0.00 0.000	1.35 0.375	0. 0.	359.01 100.000
4.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	2.2513E-06	253.12 69.619	23.43 6.443	76.54 21.053	0.03 0.008	10.46 2.877	0. 0.	363.58 100.000
4.0000	800.00	2.6585E-04	9.0223E-00	3.7690E-03	8.6310E-03	238.26 62.867	30.58 8.069	68.84 18.164	0.58 0.153	40.73 10.747	0. 0.	378.99 100.000
4.0000	1000.00	4.9018E-02	3.7523E-00	6.4774E-01	1.4681E-02	210.20 51.031	42.18 10.240	52.38 12.716	5.44 1.321	101.71 24.692	0. 0.	411.91 100.000
4.0000	1200.00	2.6875E-00	1.9714E-00	3.0042E-00	8.4703E-00	177.78 38.263	48.25 10.385	26.03 5.602	25.72 5.536	186.84 40.213	0. 0.	464.61 100.000

CALIFORNIA RESEARCH
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RE 647666

TABLE F-13B

PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - C6H14 (100 MOLE % BASIS), STEAM/C RATIO, 3.0

C(ATOMS)	ELEMENTAL COMPOSITION			RT	EQUILIBRIUM PRODUCT COMPOSITIONS									
	H(ATOMS)	O(ATOMS)	N2(MOLES)		H2O MOLES MOL PC	CO2 MOLES MOL PC	CH4 MOLES MOL PC	CO MOLES MOL PC	H2 MOLES MOL PC	N2 MOLES MOL PC	TOTAL MOLES MOL PC			
100.00	833.33	300.00	0.											
	CONDITIONS AND EQUILIBRIUM CONSTANTS	KR	KS	KC	RT	H2O MOLES MOL PC	CO2 MOLES MOL PC	CH4 MOLES MOL PC	CO MOLES MOL PC	H2 MOLES MOL PC	N2 MOLES MOL PC			
4.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E 01	1.9173E 00	162.31 31.994	42.38 8.353	4.68 0.923	52.94 10.436	244.99 48.294	0. 0.	507.30 100.000		
4.0000	1600.00	8.2139E 02	8.2439E 01	4.0069E 02	1.0889E 00	165.36 32.060	35.09 6.804	0.45 0.087	64.46 12.498	250.41 48.551	0. 0.	515.77 100.001		
4.0000	1800.00	6.7984E 03	6.0833E 01	8.3445E 03	7.7356E 01	170.43 32.994	29.62 5.735	0.05 0.011	70.32 13.614	246.13 47.647	0. 0.	516.56 100.000		
4.0000	2000.00	4.0014E 04	4.7516E 01	2.2622E 03	5.9379E 01	174.50 33.776	25.51 4.937	0.01 0.002	74.49 14.417	242.14 46.868	0. 0.	516.65 100.000		
4.0000	2200.00	1.8036E 05	3.8864E 01	7.5373E 04	4.8061E 01	177.60 34.374	22.40 4.336	0.00 0.000	77.59 15.019	239.06 46.271	0. 0.	516.66 100.000		
6.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	6.5605E 09	257.78 71.829	21.11 5.882	78.89 21.982	0.00 0.000	1.10 0.306	0. 0.	358.88 100.000		
6.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	2.2744E 06	254.04 70.053	22.97 6.333	77.01 21.236	0.02 0.007	8.60 2.372	0. 0.	362.65 100.000		
6.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	8.8774E 03	241.56 64.322	28.99 7.720	70.56 18.787	0.45 0.120	33.99 9.050	0. 0.	375.55 100.000		
6.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	1.5121E 02	217.11 53.775	39.35 9.747	56.46 13.985	4.18 1.037	86.63 21.457	0. 0.	403.74 100.000		
6.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	8.0669E 00	186.39 41.323	46.40 10.288	32.80 7.272	20.80 4.610	164.67 36.507	0. 0.	451.07 100.000		
6.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E 01	1.4568E 00	166.21 33.267	42.31 8.468	8.52 1.705	49.18 9.842	233.42 46.718	0. 0.	499.63 100.000		
6.0000	1600.00	8.2139E 02	8.2439E 01	4.0069E 02	7.3768E 01	165.87 32.226	35.12 6.823	0.98 0.191	63.90 12.415	248.83 48.345	0. 0.	514.70 100.000		
6.0000	1800.00	6.7984E 03	6.0833E 01	8.3445E 03	5.1670E 01	170.49 33.015	29.63 5.737	0.12 0.024	70.25 13.603	245.93 47.621	0. 0.	516.42 100.000		
6.0000	2000.00	4.0014E 04	4.7516E 01	2.2622E 03	3.9598E 01	174.51 33.780	25.51 4.937	0.02 0.004	74.47 14.415	242.11 46.864	0. 0.	516.62 100.000		
6.0000	2200.00	1.8036E 05	3.8864E 01	7.5373E 04	3.2043E 01	177.60 34.375	22.40 4.336	0.00 0.001	77.59 15.018	239.06 46.270	0. 0.	516.66 100.000		
12.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	6.5840E 09	257.94 71.906	21.03 5.862	78.97 22.015	0.00 0.000	0.78 0.217	0. 0.	358.72 100.000		
12.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	2.3074E 06	255.27 70.632	22.36 6.186	77.63 21.479	0.02 0.005	6.14 1.699	0. 0.	361.41 100.000		
12.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	9.2533E 03	246.09 66.354	26.81 7.228	72.90 19.655	0.30 0.081	24.78 6.683	0. 0.	370.87 100.000		
12.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	1.5955E 02	227.12 57.905	35.10 8.949	62.22 15.863	2.68 0.684	65.11 16.599	0. 0.	392.23 100.000		
12.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	7.8753E 00	200.71 46.689	42.68 9.928	43.39 10.093	13.93 3.241	129.18 30.050	0. 0.	429.89 100.000		
12.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E 01	1.0580E 00	176.70 36.835	41.78 8.710	18.48 3.853	39.73 8.283	203.00 42.319	0. 0.	479.70 100.000		
12.0000	1600.00	8.2139E 02	8.2439E 01	4.0069E 02	3.9787E 01	168.25 33.006	35.22 6.909	3.46 0.679	61.32 12.029	241.49 47.376	0. 0.	509.74 100.000		
12.0000	1800.00	6.7984E 03	6.0833E 01	8.3445E 03	2.6102E 01	170.83 33.125	29.65 5.750	0.48 0.093	69.87 13.549	244.88 47.484	0. 0.	515.71 100.000		
12.0000	2000.00	4.0014E 04	4.7516E 01	2.2622E 03	1.9833E 01	174.57 33.799	25.51 4.939	0.08 0.016	74.41 14.406	241.93 46.840	0. 0.	516.50 100.000		
12.0000	2200.00	1.8036E 05	3.8864E 01	7.5373E 04	1.6027E 01	177.61 34.379	22.40 4.337	0.02 0.003	77.58 15.016	239.02 46.265	0. 0.	516.63 100.000		

TABLE F-14A

PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - C6H14 (100 MOL C BASIS), STEAM/C RATIO, 4.0

ELEMENTAL COMPOSITION				EQUILIBRIUM PRODUCT COMPOSITIONS												
C(ATOMS)	H(ATOMS)	O(ATOMS)	N2(MOLS)	CONDITIONS AND EQUILIBRIUM CONSTANTS			RT	H2O MOLS MOL PC	CO2 MOLS MOL PC	CH4 MOLS MOL PC	CO MOLS MOL PC	H2 MOLS MOL PC	N2 MOLS MOL PC	TOTAL MOLS MOL PC		
100.00	1033.33	400.00	0.	P(ATM)	T(DEG F)	KR	KS	KC	RT	H2O MOLS MOL PC	CO2 MOLS MOL PC	CH4 MOLS MOL PC	CO MOLS MOL PC	H2 MOLS MOL PC	N2 MOLS MOL PC	TOTAL MOLS MOL PC
1.0000	400.0	7.9414E-12	2.0711E 02	4.0007E 09	9.0817E 09	356.56	21.72	78.28	0.00	3.55	0.	460.11				
						77.494	4.721	17.013	0.000	0.772	0.	100.00				
1.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	2.9166E 06	345.16	27.38	72.55	0.07	26.40	0.	471.57				
						73.195	5.807	15.385	0.014	5.599	0.	100.00				
1.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	1.0613E 04	312.24	43.16	55.40	1.43	93.62	0.	505.86				
						61.725	8.532	10.952	0.284	18.507	0.	100.00				
1.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	2.1810E 02	263.48	61.92	25.40	12.68	202.37	0.	565.86				
						46.563	10.943	4.489	2.240	35.764	0.	100.00				
1.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	3.0531E 01	240.94	61.93	2.87	35.20	269.99	0.	610.93				
						39.438	10.137	0.469	5.762	44.194	0.	100.00				
1.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	1.4512E 01	247.57	52.59	0.15	47.26	268.79	0.	616.36				
						40.166	8.532	0.025	7.668	43.610	0.	100.00				
1.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	8.9757E 00	255.39	44.62	0.01	55.37	261.25	0.	616.64				
						41.417	7.236	0.02	8.979	42.366	0.	100.00				
1.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	6.2470E 00	261.58	38.42	0.00	61.58	255.08	0.	616.66				
						42.419	6.230	0.000	9.986	41.364	0.	100.00				
1.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	4.6971E 00	266.41	33.59	0.00	66.41	250.26	0.	616.66				
						43.202	5.447	0.000	10.769	40.582	0.	100.00				
1.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	3.7444E 00	270.13	29.87	0.00	70.13	246.53	0.	616.66				
						43.806	4.843	0.000	11.373	39.978	0.	100.00				
2.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	9.0995E 09	357.07	21.46	78.54	0.00	2.52	0.	459.59				
						77.693	4.670	17.088	0.000	0.549	0.	100.00				
2.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	3.0109E 06	348.79	25.58	74.37	0.04	19.13	0.	467.92				
						74.540	5.467	15.894	0.010	4.189	0.	100.00				
2.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	1.1171E 04	323.49	37.80	61.29	0.91	70.60	0.	494.09				
						65.472	7.650	12.404	0.185	14.288	0.	100.00				
2.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	2.0623E 02	281.07	55.20	36.37	8.53	163.05	0.	544.12				
						51.656	10.144	6.666	1.568	29.965	0.	100.00				
2.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	1.8639E 01	247.87	60.47	8.34	31.20	252.11	0.	599.99				
						41.313	10.078	1.390	5.199	42.020	0.	100.00				
2.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	7.3589E 00	248.07	52.53	0.60	46.87	267.40	0.	615.47				
						40.306	8.535	0.097	7.615	43.447	0.	100.00				
2.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	4.4928E 00	255.43	44.62	0.05	55.33	261.14	0.	616.57				
						41.428	7.237	0.008	8.974	42.353	0.	100.00				
2.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	3.1239E 00	261.59	38.42	0.01	61.58	255.06	0.	616.65				
						42.421	6.230	0.001	9.986	41.363	0.	100.00				
2.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	2.3486E 00	266.41	33.59	0.00	66.41	250.25	0.	616.66				
						43.202	5.447	0.000	10.769	40.582	0.	100.00				
2.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	1.8722E 00	270.13	29.87	0.00	70.13	246.53	0.	616.66				
						43.806	4.843	0.000	11.373	39.978	0.	100.00				
4.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	9.2122E 09	357.44	21.28	78.72	0.00	1.79	0.	459.23				
						77.835	4.634	17.142	0.000	0.390	0.	100.00				
4.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	3.0878E 06	351.46	24.26	75.71	0.03	13.78	0.	465.24				
						75.543	5.214	16.274	0.006	2.963	0.	100.00				
4.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	1.1752E 04	332.33	33.54	65.87	0.59	52.59	0.	484.92				
						68.534	6.916	13.584	0.121	10.844	0.	100.00				
4.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	2.0678E 02	297.34	48.56	45.89	5.55	127.54	0.	524.88				
						56.648	9.251	8.743	1.058	24.300	0.	100.00				
4.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	1.3716E 01	260.45	57.44	17.89	24.66	220.43	0.	580.88				
						44.837	9.889	3.080	4.246	37.948	0.	100.00				

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TABLE F-148

PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - C6H14 (100 MOL % BASIS), STEAM/C RATIO, 4.0

ELEMENTAL COMPOSITION				EQUILIBRIUM PRODUCT COMPOSITIONS											
C(ATOMS)	H(ATOMS)	O(ATOMS)	N2(MOLS)	RT	H2O MOLS MOL PC	CO2 MOLS MOL PC	CH4 MOLS MOL PC	CO MOLS MOL PC	H2 MOLS MOL PC	N2 MOLS MOL PC	TOTAL MOLS MOL PC				
100.00	1933.33	400.00	0.												
CONDITIONS AND EQUILIBRIUM CONSTANTS	KR	KS	KC	RT	H2O MOLS MOL PC	CO2 MOLS MOL PC	CH4 MOLS MOL PC	CO MOLS MOL PC	H2 MOLS MOL PC	N2 MOLS MOL PC	TOTAL MOLS MOL PC				
P(ATM) T(DEG F)															
4.0000 1400.00	6.3697E 01	1.2081E 00	2.7306E-01	3.8728E 00	249.88 40.813	52.32 8.546	2.20 0.363	45.47 7.427	262.38 42.854	0. 0.	612.26 100.000				
4.0000 1600.00	8.2139E 02	8.2439E-01	4.0069E-02	2.2562E 00	255.59 41.473	44.61 7.239	0.20 0.032	55.19 8.956	260.69 42.301	0. 0.	616.27 100.000				
4.0000 1800.00	6.7984E 03	6.0833E-01	8.3445E-03	1.5628E 00	261.61 42.426	38.42 6.230	0.02 0.004	61.56 9.983	255.01 41.356	0. 0.	616.62 100.000				
4.0000 2000.00	4.0014E 04	4.7516E-01	2.2622E-03	1.1744E 00	266.41 43.203	33.59 5.447	0.00 0.001	66.40 10.768	250.24 40.582	0. 0.	616.66 100.000				
4.0000 2200.00	1.8036E 05	3.8864E-01	7.5373E-04	9.3612E-01	270.13 43.806	29.87 4.843	0.00 0.000	70.13 11.373	246.53 39.978	0. 0.	616.66 100.000				
6.0000 400.00	7.9414E-12	2.0711E 02	4.0007E 09	9.0463E 09	357.60 77.898	21.20 4.618	78.80 17.165	0.02 0.000	1.46 0.319	0. 0.	459.16 100.000				
6.0000 600.00	2.1990E-07	3.1479E 01	1.0438E 06	3.1255E 06	352.67 76.003	23.65 5.098	76.32 16.448	0.02 0.005	11.35 2.447	0. 0.	464.62 100.000				
6.0000 800.00	2.6585E-04	9.0223E 00	3.7690E 03	1.2082E 04	336.54 70.027	31.50 6.555	68.04 14.158	0.46 0.095	44.05 9.165	0. 0.	480.28 100.000				
6.0000 1000.00	4.9018E-02	3.7523E 00	6.4774E 01	2.1015E 02	305.79 59.358	44.96 8.728	50.75 9.851	4.29 0.832	109.37 21.231	0. 0.	515.16 100.000				
6.0000 1200.00	2.6875E 00	1.9714E 00	3.0042E 00	1.2392E 01	269.56 47.493	54.98 9.686	24.54 4.323	20.49 3.609	198.03 34.889	0. 0.	567.59 100.000				
6.0000 1400.00	6.3697E 01	1.2081E 00	2.7306E-01	2.7747E 00	252.39 41.521	52.02 8.557	4.40 0.724	43.58 7.169	255.47 42.028	0. 0.	607.86 100.000				
6.0000 1600.00	8.2139E 02	8.2439E-01	4.0069E-02	1.5149E 00	255.84 41.546	44.60 7.242	0.44 0.071	54.97 8.926	259.95 42.214	0. 0.	615.79 100.000				
6.0000 1800.00	6.7984E 03	6.0833E-01	8.3445E-03	1.0427E 00	261.64 42.435	38.42 6.231	0.05 0.009	61.53 9.980	254.92 41.346	0. 0.	616.56 100.000				
6.0000 2000.00	4.0014E 04	4.7516E-01	2.2622E-03	7.8304E-01	266.42 43.204	33.59 5.447	0.01 0.001	66.40 10.768	250.23 40.579	0. 0.	616.65 100.000				
6.0000 2200.00	1.8036E 05	3.8864E-01	7.5373E-04	6.2410E-01	270.14 43.806	29.87 4.843	0.00 0.000	70.13 11.373	246.53 39.977	0. 0.	616.66 100.000				
12.0000 400.00	7.9414E-12	2.0711E 02	4.0007E 09	9.1098E 09	357.81 77.981	21.99 4.597	78.91 17.197	0.00 0.000	1.04 0.226	0. 0.	458.85 100.000				
12.0000 600.00	2.1990E-07	3.1479E 01	1.0438E 06	3.1774E 06	354.28 76.617	22.85 4.942	77.13 16.681	0.02 0.004	8.12 1.757	0. 0.	462.40 100.000				
12.0000 800.00	2.6585E-04	9.0223E 00	3.7690E 03	1.2607E 04	342.33 72.125	28.68 6.043	71.02 14.962	0.30 0.063	32.30 6.806	0. 0.	474.63 100.000				
12.0000 1000.00	4.9018E-02	3.7523E 00	6.4774E 01	2.1870E 02	318.21 63.488	39.52 7.886	57.73 11.518	2.75 0.548	83.00 16.560	0. 0.	501.21 100.000				
12.0000 1200.00	2.6875E 00	1.9714E 00	3.0042E 00	1.1395E 01	285.86 52.458	50.01 9.178	35.87 6.582	14.12 2.591	159.07 29.191	0. 0.	544.93 100.000				
12.0000 1400.00	6.3697E 01	1.2081E 00	2.7306E-01	1.7846E 00	260.79 43.948	50.84 8.567	11.63 1.960	37.53 6.325	232.61 39.200	0. 0.	593.41 100.000				
12.0000 1600.00	8.2139E 02	8.2439E-01	4.0069E-02	7.8538E-01	257.12 41.918	44.53 7.259	1.64 0.268	53.83 8.776	256.27 41.779	0. 0.	613.38 100.000				
12.0000 1800.00	6.7984E 03	6.0833E-01	8.3445E-03	5.2377E-01	261.80 42.484	38.41 6.234	0.22 0.035	61.37 9.959	254.43 41.288	0. 0.	616.23 100.000				
12.0000 2000.00	4.0014E 04	4.7516E-01	2.2622E-03	3.9182E-01	266.45 43.213	33.59 5.448	0.04 0.006	66.37 10.764	250.15 40.569	0. 0.	616.59 100.000				
12.0000 2200.00	1.8036E 05	3.8864E-01	7.5373E-04	3.1210E-01	270.14 43.808	29.87 4.843	0.01 0.001	70.13 11.372	246.51 39.975	0. 0.	616.65 100.000				

TABLE F-15A
PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - C6H14 (100 MOL % BASIS), STEAM/C RATIO, 5.0												
ELEMENTAL COMPOSITION				EQUILIBRIUM PRODUCT COMPOSITIONS								
C(ATOMS)	H(ATOMS)	O(ATOMS)	N2(MOLS)		H2O	CO2	CH4	CO	H2	N2	TOTAL	
120.00	1233.33	500.00	0.		MOL	MOL	MOL	MOL	MOL	MOL	MOL	
P(ATM)	T(DEG F)	KR	KS	KC	RT	MOL PC	MOL PC	MOL PC	MOL PC	MOL PC	MOL PC	
1.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	1.1679E 10	456.12 81.371	21.94 3.914	78.06 13.926	0.00 0.000	4.42 0.789	0. 0.	560.54 100.000
1.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	3.6759E 06	442.18 76.960	28.88 5.026	71.05 12.367	0.07 0.012	32.38 5.636	0. 0.	574.56 100.000
1.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	1.3606E 04	403.10 65.541	47.72 7.758	50.81 8.262	1.47 0.239	111.94 18.200	0. 0.	615.04 100.000
1.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	3.1927E 02	349.45 51.438	69.21 10.188	18.65 2.746	12.14 1.786	229.91 33.842	0. 0.	679.35 100.000
1.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	5.6204E 01	332.49 46.582	68.96 9.661	1.45 0.203	29.59 4.146	281.28 39.408	0. 0.	713.77 100.000
1.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	2.6561E 01	340.31 47.495	59.77 8.342	0.08 0.011	40.15 5.604	276.21 38.549	0. 0.	716.51 100.000
1.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	1.5877E 01	348.32 48.603	51.69 7.213	0.01 0.001	48.30 6.740	268.34 37.443	0. 0.	716.65 100.000
1.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	1.0777E 01	354.82 49.509	45.18 6.305	0.00 0.000	54.81 7.649	261.85 36.537	0. 0.	716.66 100.000
1.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	7.9600E 00	360.01 50.234	39.99 5.581	0.00 0.000	60.01 8.373	256.66 35.813	0. 0.	716.66 100.000
1.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	6.2645E 00	364.09 50.804	35.91 5.010	0.00 0.000	64.09 8.943	252.57 35.243	0. 0.	716.66 100.000
2.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	1.1767E 10	456.76 81.579	21.62 3.861	78.38 13.999	0.00 0.000	3.14 0.561	0. 0.	559.90 100.000
2.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	3.8031E 06	446.58 78.328	26.69 4.681	73.27 12.851	0.04 0.008	23.56 4.132	0. 0.	570.13 100.000
2.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	1.4161E 04	416.27 69.225	41.40 6.884	57.67 9.590	0.94 0.156	85.06 14.145	0. 0.	601.33 100.000
2.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	2.8192E 02	367.83 55.958	61.84 9.408	29.67 4.513	8.49 1.292	189.50 28.829	0. 0.	657.33 100.000
2.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	3.1626E 01	337.08 47.671	67.71 9.575	4.78 0.676	27.51 3.891	270.02 38.187	0. 0.	707.10 100.000
2.0000	1400.00	6.3697E 01	1.2081E 00	2.7406E-01	1.3376E 01	340.58 47.563	59.72 8.340	0.30 0.042	39.98 5.583	275.48 38.472	0. 0.	716.06 100.000
2.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	7.9428E 00	348.34 48.609	51.69 7.213	0.03 0.004	48.29 6.738	268.28 37.437	0. 0.	716.61 100.000
2.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	5.3890E 00	354.82 49.510	45.18 6.305	0.00 0.000	54.81 7.648	261.84 36.536	0. 0.	716.66 100.000
2.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	3.9800E 00	360.01 50.234	39.99 5.581	0.00 0.000	60.01 8.373	256.66 35.813	0. 0.	716.66 100.000
2.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	3.1322E 00	364.09 50.804	35.91 5.010	0.00 0.000	64.09 8.943	252.57 35.243	0. 0.	716.66 100.000
4.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	1.1623E 10	457.22 81.727	21.39 3.824	78.61 14.051	0.00 0.000	2.23 0.399	0. 0.	559.45 100.000
4.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	3.9097E 06	449.83 79.355	25.07 4.422	74.90 13.213	0.03 0.005	17.03 3.004	0. 0.	566.86 100.000
4.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	1.4819E 04	426.75 72.268	36.32 6.151	63.07 10.681	0.60 0.102	63.76 10.798	0. 0.	590.52 100.000
4.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	2.7156E 02	385.90 60.638	54.23 8.522	40.13 6.306	5.64 0.886	150.50 23.649	0. 0.	636.40 100.000
4.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	2.0920E 01	347.44 50.182	64.71 9.346	12.15 1.755	23.14 3.342	244.92 35.375	0. 0.	692.36 100.000

CALIFORNIA RESEARCH
CORPORATION
RICHMOND, CALIFORNIA

RE 647670

TABLE F-15B

PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - C₆H₁₄ (100 MOLE % BASIS), STEAM/C RATIO, 5.0

P(ATM)	T(DEG F)	ELEMENTAL COMPOSITION			RT	EQUILIBRIUM PRODUCT COMPOSITIONS								TOTAL MOLES
		C(ATOMS)	H(ATOMS)	O(ATOMS)		N2(MOLS)	H2O MOL PC	CO2 MOL PC	CH4 MOL PC	CO MOL PC	H2 MOL PC	N2 MOL PC	MOL PC	
100.00		1233.33	500.00	0.										
4.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	6.8717E 00	341.63 47.823	59.52 8.332	1.15 0.161	39.33 5.506	272.74 38.179	0. 0.			714.37 100.000
4.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	3.9804E 00	348.42 48.631	51.68 7.213	0.10 0.014	48.22 6.731	268.04 37.411	0. 0.			716.46 100.000
4.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	2.6953E 00	354.83 49.513	45.18 6.305	0.01 0.002	54.80 7.647	261.81 36.533	0. 0.			716.54 100.000
4.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	1.9901E 00	360.01 50.234	39.99 5.581	0.00	60.00 8.373	256.65 35.812	0. 0.			716.66 100.000
4.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	1.5661E 00	364.09 50.804	35.91 5.010	0.00 0.000	64.09 8.943	252.57 35.243	0. 0.			716.66 100.000
6.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	1.1691E 10	457.42 81.793	21.29 3.807	78.71 14.074	0.03 0.000	1.82 0.326	0. 0.			559.24 100.000
6.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	3.9614E 06	451.32 79.826	24.33 4.303	75.65 13.380	0.02 0.004	14.05 2.485	0. 0.			565.37 100.000
6.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	1.5216E 04	431.77 73.762	33.88 5.788	65.65 11.216	0.47 0.080	53.59 9.155	0. 0.			585.36 100.000
6.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	2.7191E 02	395.56 63.240	50.03 7.999	45.59 7.289	4.38 0.700	129.93 20.772	0. 0.			625.49 100.000
6.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	1.7918E 01	356.12 52.343	62.03 9.118	18.15 2.668	19.81 2.912	224.24 32.959	0. 0.			680.36 100.000
6.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	4.7731E 00	343.20 48.214	59.22 8.319	2.42 0.340	38.37 5.390	268.63 37.738	0. 0.			711.83 100.000
6.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	2.6636E 00	348.57 48.668	51.66 7.213	0.23 0.032	48.12 6.718	267.65 37.370	0. 0.			716.21 100.000
6.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	1.7977E 00	354.85 49.518	45.18 6.305	0.03 0.004	54.79 7.646	261.76 36.528	0. 0.			716.61 100.000
6.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	1.3268E 00	360.01 50.235	39.99 5.581	0.00 0.001	60.00 8.372	256.64 35.811	0. 0.			716.66 100.000
6.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	1.0441E 00	364.09 50.804	35.91 5.010	0.00 0.000	64.09 8.943	252.57 35.242	0. 0.			716.66 100.000
12.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	1.1725E 10	457.69 81.879	21.16 3.785	78.84 14.105	0.00 0.000	1.29 0.231	0. 0.			558.98 100.000
12.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	4.0367E 06	453.30 80.462	23.34 4.143	76.64 13.604	0.02 0.003	10.07 1.788	0. 0.			563.38 100.000
12.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	1.5876E 04	438.73 75.875	30.48 5.271	69.22 11.970	0.30 0.053	39.50 4.831	0. 0.			578.23 100.000
12.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	2.7848E 02	409.99 67.267	43.60 7.153	53.59 8.792	2.82 0.463	99.50 16.326	0. 0.			609.49 100.000
12.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	1.5451E 01	373.13 56.736	56.36 8.570	29.50 4.485	14.14 2.150	184.53 28.059	0. 0.			657.67 100.000
12.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	2.8178E 00	349.38 49.770	57.97 8.258	7.34 1.046	34.69 4.942	252.61 35.985	0. 0.			701.98 100.000
12.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	1.3581E 00	349.31 48.860	51.56 7.213	0.88 0.122	47.56 6.653	265.60 37.152	0. 0.			714.91 100.000
12.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	9.0103E 01	354.94 49.542	45.17 6.305	0.11 0.016	54.71 7.637	261.50 36.500	0. 0.			716.44 100.000
12.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	6.6369E-01	360.03 50.239	39.99 5.581	0.02 0.003	59.99 8.371	256.60 35.806	0. 0.			716.63 100.000
12.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	5.2210E-01	364.10 50.805	35.91 5.010	0.00 0.001	64.09 8.943	252.56 35.241	0. 0.			716.66 100.000

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TABLE F-16

PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - C9H20 (100 MOLE % BASIS), STEAM/C RATIO, 1.0

ELEMENTAL COMPOSITION				EQUILIBRIUM PRODUCT COMPOSITIONS											
C(ATM)	H(ATM)	O(ATM)	N2(MOL%)	CONDITIONS AND EQUILIBRIUM CONSTANTS			RT	H2O MOL%	CO2 MOL%	CH4 MOL%	CO MOL%	H2 MOL%	N2 MOL%	TOTAL MOL%	
100.0	422.22	100.00	C.	KR	KS	KC		MOL PC	MOL PC	MOL PC	MOL PC	MOL PC	MOL PC	MOL PC	
1.0000	1600.00	8.2135E-02	8.2439E-01	4.0065E-02	3.5432E-02	2.71	1.06	3.76	95.18	200.87	6.0	303.58	C.	100.000	
CONDITIONS LEAD TO CARBON FORMATION.				0.892	0.348	1.240	31.352	66.168							
1.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	9.4380E-03	1.03	0.30	1.32	98.38	207.44	0.0	308.46	C.	100.000	
1.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	3.1167E-03	0.44	0.16	0.54	99.36	209.59	0.0	310.03	C.	100.000	
1.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	1.2216E-03	0.21	0.04	0.25	99.71	210.39	0.0	310.61	C.	100.000	
2.0000	1600.00	8.2135E-02	8.2439E-01	4.0065E-02	3.5432E-02	5.06	1.92	7.03	90.99	191.99	0.0	297.45	C.	100.000	
CONDITIONS LEAD TO CARBON FORMATION.				1.762	0.665	2.367	30.633	64.634							
2.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	9.4381E-03	2.00	0.56	2.58	96.84	203.95	0.0	305.95	C.	100.000	
2.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	3.1152E-03	0.87	0.20	1.07	98.73	208.10	0.0	308.97	C.	100.000	
2.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	1.2212E-03	0.42	0.08	0.56	99.42	209.69	0.0	310.11	C.	100.000	
4.0000	1600.00	8.2135E-02	8.2439E-01	4.0065E-02	3.5420E-02	8.95	3.50	12.44	84.06	177.27	0.0	286.22	C.	100.000	
CONDITIONS LEAD TO CARBON FORMATION.				3.126	1.222	4.348	29.368	61.936							
4.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	9.4177E-03	3.81	1.10	4.92	93.98	197.46	0.0	301.27	C.	100.000	
4.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	3.1122E-03	1.71	0.39	2.69	97.52	205.71	0.0	306.92	C.	100.000	
4.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	1.2206E-03	0.84	0.15	0.99	98.85	208.29	0.0	309.13	C.	100.000	
6.0000	1600.00	8.2135E-02	8.2439E-01	4.0065E-02	3.5410E-02	12.06	4.72	16.78	78.52	165.49	0.0	277.55	C.	100.000	
CONDITIONS LEAD TO CARBON FORMATION.				4.346	1.700	6.046	28.284	59.624							
6.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	9.4050E-03	5.47	1.59	7.05	91.36	191.54	0.0	297.01	C.	100.000	
6.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	3.1094E-03	2.51	0.57	3.08	76.35	202.44	0.0	304.95	C.	100.000	
6.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	1.2195E-03	1.24	0.23	1.47	98.30	206.92	0.0	308.16	C.	100.000	
12.0000	1600.00	8.2135E-02	8.2439E-01	4.0065E-02	3.5386E-02	18.65	7.30	25.95	66.75	140.57	0.0	259.22	C.	100.000	
CONDITIONS LEAD TO CARBON FORMATION.				7.193	2.816	1.069	25.752	54.229							
12.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	9.3699E-03	9.66	2.82	12.48	84.70	176.50	0.0	286.16	C.	100.000	
12.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	3.1010E-03	4.74	1.08	5.82	93.10	194.71	0.0	299.47	C.	100.000	
12.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	1.2179E-03	2.42	0.45	2.86	96.69	202.97	0.0	305.38	C.	100.000	

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TABLE F-17A

PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - C9H20 (100 MOL % BASIS), STEAM/C RATIO, 2.0

C(ATOMS) 100.00	ELEMENTAL COMPOSITION			RT	EQUILIBRIUM PRODUCT COMPOSITIONS								TOTAL MOLS MOL PC
	H(ATOMS) 622.22	O(ATOMS) 200.00	N2(MOLS) 0.		H2O MOLS MOL PC	CO2 MOLS MOL PC	CH4 MOLS MOL PC	CO MOLS MOL PC	H2 MOLS MOL PC	N2 MOLS MOL PC			
1.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	3.8980E-09	154.69 60.329	22.65 8.834	77.35 30.164	0.00 0.000	1.72 0.672	0. 0.	256.42 100.000	
CONDITIONS LEAD TO CARBON FORMATION.													
1.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	1.2881E-06	148.96 56.809	25.48 9.718	74.45 28.391	0.07 0.027	13.25 5.754	0. 0.	262.22 100.000	
1.0000	800.00	2.6585E-04	9.0223E-00	3.7690E-03	4.6652E-03	131.22 46.645	33.68 11.972	64.90 23.069	1.43 0.507	50.10 17.808	0. 0.	281.32 100.000	
1.0000	1000.00	4.9018E-02	3.7523E-00	6.4774E-01	7.7316E-01	102.08 31.673	42.32 13.129	44.40 13.776	13.28 4.121	120.22 37.301	0. 0.	322.31 100.000	
1.0000	1200.00	2.6875E-00	1.9714E-00	3.0042E-00	5.7639E-01	77.42 20.214	36.62 9.562	14.05 3.667	49.33 12.880	205.60 53.678	0. 0.	383.02 100.000	
1.0000	1400.00	6.3697E-01	1.2081E-00	2.7306E-01	2.1723E-00	73.94 18.090	27.24 6.663	1.18 0.288	71.59 17.513	234.81 57.446	0. 0.	408.75 100.000	
1.0000	1600.00	8.2139E-02	8.2439E-01	4.0069E-02	1.4601E-00	78.37 19.071	21.72 5.286	0.09 0.022	78.19 19.027	232.56 56.594	0. 0.	410.93 100.000	
1.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	1.0924E-00	82.11 19.973	17.90 4.355	0.01 0.003	82.08 19.968	228.98 55.702	0. 0.	411.09 100.000	
1.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	8.6348E-01	84.87 20.645	15.13 3.680	0.00 0.000	84.87 20.644	226.23 55.030	0. 0.	411.11 100.000	
1.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	7.1264E-01	86.91 21.140	13.09 3.185	0.00 0.000	86.91 21.140	224.20 54.536	0. 0.	411.11 100.000	
2.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	3.9167E-09	154.94 60.486	22.53 8.794	77.47 30.243	0.00 0.000	1.22 0.477	0. 0.	256.17 100.000	
CONDITIONS LEAD TO CARBON FORMATION.													
2.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	1.3200E-06	150.82 57.934	24.56 9.435	75.39 28.958	0.05 0.019	9.51 3.654	0. 0.	260.34 100.000	
2.0000	800.00	2.6585E-04	9.0223E-00	3.7690E-03	4.9822E-03	137.47 50.068	30.81 11.220	68.27 24.866	0.92 0.336	37.09 13.510	0. 0.	274.56 100.000	
2.0000	1000.00	4.9018E-02	3.7523E-00	6.4774E-01	8.2265E-01	113.38 37.020	39.05 12.750	52.43 17.118	8.53 2.784	92.88 30.328	0. 0.	306.26 100.000	
2.0000	1200.00	2.6875E-00	1.9714E-00	3.0042E-00	4.8273E-00	87.78 24.336	37.41 10.372	25.20 6.985	37.39 10.365	172.93 47.942	0. 0.	360.72 100.000	
2.0000	1400.00	6.3697E-01	1.2081E-00	2.7306E-01	1.2006E-00	76.29 18.929	27.74 6.882	4.03 1.000	68.23 16.929	226.75 56.260	0. 0.	403.95 100.000	
2.0000	1600.00	8.2139E-02	8.2439E-01	4.0069E-02	7.3645E-01	78.59 19.150	21.77 5.304	0.36 0.087	77.88 18.976	231.81 56.483	0. 0.	410.40 100.000	
2.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	5.4674E-01	82.13 19.982	17.91 4.357	0.04 0.010	82.05 19.962	228.89 55.680	0. 0.	411.03 100.000	
2.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	4.3181E-01	84.88 20.647	15.13 3.680	0.01 0.002	84.86 20.643	226.22 55.028	0. 0.	411.10 100.000	
2.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	3.5633E-01	86.91 21.140	13.09 3.185	0.00 0.000	86.91 21.139	224.20 54.535	0. 0.	411.11 100.000	
4.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	3.9033E-09	155.12 60.598	22.44 8.765	77.56 30.299	0.00 0.000	3.87 0.338	0. 0.	255.99 100.000	
CONDITIONS LEAD TO CARBON FORMATION.													
4.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	1.3441E-06	152.17 58.760	23.90 9.228	76.07 29.373	0.03 0.013	6.80 2.626	0. 0.	438.97 100.000	
4.0000	800.00	2.6585E-04	9.0223E-00	3.7690E-03	5.2569E-03	142.26 52.798	28.57 10.601	70.83 26.287	0.61 0.225	27.19 10.089	0. 0.	269.45 100.000	
4.0000	1000.00	4.9018E-02	3.7523E-00	6.4774E-01	6.8113E-01	123.05 41.922	35.75 12.179	58.80 20.031	5.46 1.859	70.47 24.009	0. 0.	293.52 100.000	
4.0000	1200.00	2.6875E-00	1.9714E-00	3.0042E-00	4.5532E-00	99.63 29.422	37.16 10.995	36.58 10.826	26.26 7.770	138.51 40.987	0. 0.	337.94 100.000	

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TABLE F-17B

PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - C9H2O (100 MOL % BASIS), STEAM/C RATIO, 2.0

ELEMENTAL COMPOSITION												
C(ATOMS)	H(ATOMS)	O(ATOMS)	N2(MOLS)									
100.00	622.22	200.00	0.									
CONDITIONS AND EQUILIBRIUM CONSTANTS												
P(ATM)	T(DEG F)	KR	KS	KC	RT	H2O MOLS MOL PC	CO2 MOLS MOL PC	CH4 MOLS MOL PC	EQUILIBRIUM PRODUCT COMPOSITIONS			
									CO H2 N2 TOTAL MOLS MOL PC MOLS MOL PC MOLS MOL PC MOLS MOL PC			
4.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	7.7144E-01	82.03 21.067	28.83 7.403	10.86 2.789	60.31 15.489	207.36 53.252	0. 0.	389.39 100.000
4.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	3.8057E-01	79.42 19.447	21.93 5.371	1.35 0.332	76.71 18.783	228.98 56.068	0. 0.	408.40 100.000
4.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	2.7446E-01	82.24 20.020	17.93 4.365	0.17 0.040	81.91 19.939	228.54 55.636	0. 0.	410.78 100.000
4.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	2.1604E-01	84.90 20.653	15.13 3.681	0.03 0.007	84.84 20.640	226.16 55.019	0. 0.	411.06 100.000
4.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	1.7819E-01	86.91 21.142	13.09 3.185	0.01 0.001	86.89 21.139	224.19 54.533	0. 0.	411.10 100.000
6.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	3.9451E-09	155.20 60.647	22.40 8.753	77.60 30.324	0.00 0.000	0.71 0.276	0. 0.	255.91 100.000
CONDITIONS LEAD TO CARBON FORMATION.												
6.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	1.3554E 06	152.78 59.134	23.60 9.133	76.38 29.562	0.03 0.011	5.58 2.160	0. 0.	258.36 100.000
6.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	5.3963E 03	144.50 54.105	27.51 10.300	72.01 26.963	0.48 0.178	22.58 8.453	0. 0.	267.08 100.000
6.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	9.1632E 01	127.89 44.492	33.95 11.811	61.84 21.513	4.21 1.466	59.55 20.717	0. 0.	287.44 100.000
6.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	4.5436E 00	106.13 32.568	36.49 11.199	42.62 13.079	20.89 6.409	119.74 36.745	0. 0.	325.87 100.000
6.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	6.4995E-01	87.17 23.091	29.64 7.850	16.80 4.451	53.56 14.188	190.34 50.420	0. 0.	377.50 100.000
6.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	2.6641E-01	80.64 19.888	22.18 5.470	2.82 0.695	75.00 18.498	224.83 55.450	0. 0.	405.47 100.000
6.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	1.8417E-01	82.41 20.082	17.96 4.377	0.37 0.090	81.67 19.902	227.96 55.550	0. 0.	410.37 100.000
6.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	1.4418E-01	84.92 20.664	15.14 3.683	0.06 0.015	84.80 20.634	226.06 55.005	0. 0.	410.99 100.000
6.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	1.1882E-01	86.92 21.144	13.09 3.185	0.01 0.003	86.89 21.137	224.16 54.530	0. 0.	411.08 100.000
12.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	3.9532E-09	155.31 60.712	22.35 8.736	77.65 30.356	0.00 0.000	0.50 0.196	0. 0.	255.81 100.000
12.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	1.3701E 06	153.58 59.630	23.20 9.008	76.78 29.812	0.02 0.007	3.97 1.542	0. 0.	257.55 100.000
12.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	5.5982E 03	147.54 55.912	26.07 9.878	73.61 27.896	0.32 0.121	16.34 6.192	0. 0.	263.89 100.000
12.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	9.7456E 01	134.81 48.315	31.23 11.192	66.04 23.668	2.73 0.978	44.22 15.846	0. 0.	279.03 100.000
12.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	4.6607E 00	116.67 37.845	34.75 11.271	51.42 16.678	13.84 4.489	91.61 29.716	0. 0.	308.28 100.000
12.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	5.4888E-01	97.80 27.630	30.77 8.692	28.57 8.071	40.66 11.488	156.17 44.118	0. 0.	353.97 100.000
12.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	1.6088E-01	85.25 21.611	23.05 5.844	8.31 2.106	68.64 17.399	209.24 53.040	0. 0.	394.49 100.000
12.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	9.5180E-02	83.28 20.396	18.12 4.438	1.40 0.343	80.48 19.711	225.03 55.113	0. 0.	408.31 100.000
12.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	7.2504E-02	85.08 20.720	15.16 3.693	0.24 0.059	84.59 20.601	225.54 54.927	0. 0.	410.62 100.000
12.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	5.9484E-02	86.95 21.156	13.10 3.187	0.05 0.013	86.85 21.131	225.05 54.513	0. 0.	411.00 100.000

TABLE F-18A

PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - C9H20 (100 MOLE % BASIS), STEAM/C RATIO, 3.0

P(ATM)	T(DEG F)	ELEMENTAL COMPOSITION			EQUILIBRIUM PRODUCT COMPOSITIONS										TOTAL MOLES MOL PC
		C(ATOMS)	H(ATOMS)	O(ATOMS)	N2(MOLS)	RT	H2O MOLES MOL PC	CO2 MOLES MOL PC	CH4 MOLES MOL PC	CO MOLES MOL PC	H2 MOLES MOL PC	N2 MOLES MOL PC			
1.0000	500.00	7.9414E-12	2.0711E-02	4.0007E-09	6.4015E-09	254.26	22.87	77.13	0.00	2.61	0.	356.86			
						71.249	6.409	21.613	0.000	0.728	0.	100.00			
1.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	2.0833E-06	245.75	27.09	72.84	0.07	19.68	0.	365.43			
						67.249	7.414	19.932	0.019	5.386	0.	100.000			
1.0000	800.00	2.6585E-04	9.0223E-00	3.7690E-03	7.5859E-03	220.18	39.20	59.38	1.42	72.16	0.	392.35			
						56.120	9.990	15.135	0.363	18.393	0.	100.000			
1.0000	1000.00	4.9018E-02	3.7523E-00	6.4774E-01	1.3962E-02	179.83	53.56	33.39	13.06	164.50	0.	444.33			
						40.473	12.053	7.515	2.938	37.021	0.	100.000			
1.0000	1200.00	2.6875E-00	1.9714E-00	3.0042E-00	1.4720E-01	153.99	52.01	6.00	41.99	245.12	0.	499.11			
						30.853	10.420	1.202	8.414	49.111	0.	100.000			
1.0000	1400.00	6.3697E-01	1.2081E-03	2.7306E-01	6.7587E-00	157.55	42.80	0.35	56.85	252.85	0.	510.41			
						30.868	8.385	0.069	11.138	49.539	0.	100.000			
1.0000	1600.00	8.2139E-02	8.2439E-01	4.0069E-02	4.3608E-00	164.54	35.49	0.03	64.49	246.51	0.	511.06			
						32.197	6.943	0.005	12.619	48.236	0.	100.000			
1.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	3.1322E-00	169.99	30.01	0.00	69.98	241.11	0.	511.10			
						33.259	5.872	0.001	13.692	47.175	0.	100.000			
1.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	2.4973E-00	174.12	25.88	0.00	74.12	236.99	0.	511.11			
						34.068	5.063	0.000	14.502	46.367	0.	100.000			
1.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	1.9490E-00	177.25	22.75	0.00	77.25	233.86	0.	511.11			
						34.679	4.452	0.000	15.113	45.756	0.	100.000			
2.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	6.4217E-09	254.63	22.68	77.32	0.00	1.84	0.	356.48			
						71.431	6.363	21.689	0.000	0.517	0.	100.000			
2.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	2.1412E-06	248.48	25.73	74.22	0.05	14.19	0.	362.67			
						68.515	7.096	20.464	0.013	3.912	0.	100.000			
2.0000	800.00	2.6585E-04	9.0223E-00	3.7690E-03	8.0380E-03	229.06	35.01	64.07	0.91	53.91	0.	382.96			
						59.812	9.143	16.731	0.238	14.076	0.	100.000			
2.0000	1000.00	4.9018E-02	3.7523E-00	6.4774E-01	1.4021E-02	195.00	48.23	43.23	8.55	129.66	0.	424.66			
						45.919	11.357	10.179	2.012	30.532	0.	100.000			
2.0000	1200.00	2.6875E-00	1.9714E-00	3.0042E-00	1.0211E-01	163.32	50.99	14.31	34.71	219.18	0.	482.50			
						33.849	10.567	2.965	7.193	45.426	0.	100.000			
2.0000	1400.00	6.3697E-01	1.2081E-00	2.7306E-01	3.4880E-00	158.53	42.81	1.34	55.86	249.91	0.	508.44			
						31.179	8.419	0.263	10.986	49.152	0.	100.000			
2.0000	1600.00	8.2139E-02	8.2439E-01	4.0069E-02	2.1858E-00	164.62	35.49	0.11	64.40	246.27	0.	510.89			
						32.222	6.947	0.021	12.606	48.204	0.	100.000			
2.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	1.5666E-00	170.00	30.01	0.01	69.97	241.09	0.	511.08			
						33.262	5.873	0.003	13.691	47.171	0.	100.000			
2.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	1.2037E-00	174.12	25.88	0.00	74.12	236.98	0.	511.11			
						34.068	5.063	0.000	14.502	46.366	0.	100.000			
2.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	9.7449E-01	177.25	22.75	0.00	77.25	233.86	0.	511.11			
						34.679	4.452	0.000	15.113	45.756	0.	100.000			
4.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	6.4735E-09	254.90	22.55	77.45	0.00	1.31	0.	356.21			
						71.560	6.330	21.743	0.000	0.367	0.	100.000			
4.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	2.1868E-06	250.48	24.74	75.22	0.03	10.18	0.	360.66			
						69.451	6.861	20.858	0.009	2.822	0.	100.000			
4.0000	800.00	2.6585E-04	9.0223E-00	3.7690E-03	8.4626E-03	235.94	31.73	67.68	0.59	39.82	0.	375.76			
						62.791	8.445	18.010	0.158	10.596	0.	100.000			
4.0000	1000.00	4.9018E-02	3.7523E-00	6.4774E-01	1.4536E-02	208.38	43.06	51.44	5.50	99.84	0.	408.23			
						51.046	10.548	12.601	1.347	24.458	0.	100.000			
4.0000	1200.00	2.6875E-00	1.9714E-00	3.0042E-00	8.4646E-00	176.59	48.82	25.41	25.76	183.70	0.	460.28			
						30.365	10.607	5.521	5.597	39.909	0.	100.000			

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RICHMOND, CALIFORNIA
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TABLE F-18B

PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - C9H2O (100 MOLE % BASIS), STEAM/C RATIO, 3.0

C(ATOMS) 100.00	ELEMENTAL COMPOSITION			RT	EQUILIBRIUM PRODUCT COMPOSITIONS								TOTAL MOLES MOL PC
	H(ATOMS) 822.22	O(ATOMS) 300.00	N2(MOLES) 0.		H2O MOLES MOL PC	CO2 MOLES MOL PC	CH4 MOLES MOL PC	CO MOLES MOL PC	H2 MOLES MOL PC	N2 MOLES MOL PC			
4.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	1.9364E 00	161.70 32.205	42.81 8.526	4.51 0.898	52.68 10.492	240.39 47.878	0. 0.	502.09 100.000	
4.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	1.1035E 00	164.92 32.322	35.51 6.958	0.43 0.084	64.07 12.556	245.33 48.080	0. 0.	510.25 106.000	
4.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	7.8416E-01	170.03 33.274	30.02 5.874	0.05 0.010	69.93 13.685	240.97 47.156	0. 0.	511.01 100.000	
4.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	6.0197E-01	174.13 34.070	25.88 5.063	0.01 0.002	74.11 14.501	236.96 46.364	0. 0.	511.09 100.000	
4.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	4.8726E-01	177.25 34.679	22.75 4.452	0.00 0.000	77.24 15.113	233.86 45.755	0. 0.	511.11 100.000	
6.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	6.4769E 09	255.02 71.617	22.49 6.316	77.51 21.767	0.00 0.000	1.07 0.300	0. 0.	356.09 100.000	
6.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	2.2081E 06	251.38 69.877	24.29 6.753	75.68 21.037	0.03 0.007	8.37 2.326	0. 0.	359.75 100.000	
6.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	8.6900E 03	239.19 64.231	30.17 8.103	69.36 18.626	0.46 0.125	33.24 8.916	0. 0.	372.39 100.000	
6.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	1.4943E 02	215.18 53.773	40.29 10.068	55.47 13.862	4.24 1.060	84.98 21.237	0. 0.	400.17 100.000	
6.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	8.0422E 00	185.05 41.405	47.04 10.525	32.09 7.180	20.87 4.670	161.88 36.221	0. 0.	446.93 100.000	
6.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	1.4675E 00	165.48 33.454	42.76 8.644	8.23 1.665	49.01 9.908	229.17 46.329	0. 0.	494.64 100.000	
6.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	7.4717E-01	165.41 32.483	35.53 6.977	0.94 0.185	63.53 12.475	243.82 47.880	0. 0.	509.23 106.000	
6.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	5.2375E-01	170.09 33.295	30.02 5.877	0.12 0.023	69.86 13.675	240.78 47.131	0. 0.	510.88 100.000	
6.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	4.0144E-01	174.14 34.074	25.88 5.064	0.02 0.004	74.10 14.499	236.93 46.360	0. 0.	511.17 100.000	
6.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	3.2486E-01	177.25 34.680	22.75 4.452	0.00 0.001	77.24 15.113	233.85 45.754	0. 0.	511.10 100.000	
12.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	6.4740E 09	255.18 71.692	22.41 6.296	77.59 21.799	0.00 0.000	0.76 0.212	0. 0.	455.93 106.000	
12.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	2.2372E 06	252.58 70.445	23.70 6.610	76.28 21.275	0.02 0.005	5.97 1.665	0. 0.	358.55 106.000	
12.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	9.0341E 03	243.62 66.237	28.04 7.623	71.66 19.482	0.31 0.084	24.18 6.574	0. 0.	367.89 100.000	
12.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	1.5719E 02	225.03 57.876	36.12 9.290	61.15 15.727	2.73 0.702	63.78 16.405	0. 0.	388.81 100.000	
12.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	7.8225E 00	199.12 46.738	43.42 10.192	42.54 9.985	14.04 3.295	126.91 29.789	0. 0.	426.03 100.000	
12.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	1.0603E 00	175.69 36.975	42.29 8.899	17.98 3.783	39.74 8.363	199.47 41.980	0. 0.	475.16 100.000	
12.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	4.0215E-01	167.69 33.242	35.64 7.065	3.33 0.660	61.03 12.099	236.76 46.935	0. 0.	504.45 100.000	
12.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	2.6449E-01	170.41 33.401	30.05 5.889	0.46 0.090	69.50 13.622	239.78 46.998	0. 0.	510.19 100.000	
12.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	2.0105E-01	174.19 34.092	25.88 5.066	0.08 0.015	74.04 14.490	236.76 46.337	0. 0.	510.95 100.000	
12.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	1.6249E-01	177.26 34.684	22.75 4.452	0.02 0.003	77.23 15.111	233.81 45.749	0. 0.	511.08 100.000	

TABLE F-19A

PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - C9H20 (100 MOLE % BASIS), STEAM/C RATIO, 4.0

ELEMENTAL COMPOSITION			EQUILIBRIUM PRODUCT COMPOSITIONS																						
C(ATOMS)	H(ATOMS)	O(ATOMS)	N2(MOLE %)			H2O			CO2			CH4			CO			H2			N2				
100.00	1022.22	400.00	C			MOL	PC	MOL	PC	MOL	PC	MOL	PC	MOL	PC	MOL	PC	MOL	PC	MOL	PC	MOL	PC	TOTAL	
P(ATM)	T(DEG F)	KR	KS	KC	RT																			MOLS	MOL PC
1.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	8.8695E 09	353.83	23.09	76.91	0.00	3.46	0.	457.29												100.000	
1.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	2.8562E 06	342.68	28.63	71.31	0.07	25.82	0.	468.50												100.000	
1.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	1.0523E 04	310.26	44.15	54.40	1.45	92.05	0.	502.31												100.000	
1.0000	1000.00	4.9010E-02	3.7523E 00	6.4774E 01	2.1869E 02	262.22	62.55	24.77	12.67	199.35	0.	561.57												100.000	
1.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	3.1011E 01	240.39	62.36	2.75	34.90	265.22	0.	605.61												100.000	
1.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	1.4768E 01	247.12	53.02	0.15	46.83	263.69	0.	610.82												100.000	
1.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	9.1297E 00	254.95	45.07	0.01	54.92	256.14	0.	611.09												100.000	
1.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	6.3522E 00	261.14	38.86	0.00	61.14	249.96	0.	611.11												100.000	
1.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	4.7752E 00	265.98	34.02	0.00	65.98	245.13	0.	611.11												100.000	
1.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	3.8063E 00	269.72	30.28	0.00	69.72	241.39	0.	611.11												100.000	
2.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	8.8713E 09	354.33	22.84	77.16	0.00	2.46	0.	456.78												100.000	
2.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	2.9429E 06	346.23	26.86	73.09	0.05	18.69	0.	464.92												100.000	
2.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	1.1042E 04	321.35	38.86	60.21	0.93	69.33	0.	490.68												100.000	
2.0000	1000.00	4.9010E-02	3.7523E 00	6.4774E 01	2.0596E 02	279.54	55.95	35.49	8.56	160.59	0.	540.13												100.000	
2.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	1.8847E 01	247.10	60.94	8.04	31.02	247.93	0.	595.03												100.000	
2.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	7.4849E 00	247.60	52.97	0.57	46.46	262.36	0.	609.97												100.000	
2.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	4.5697E 00	254.98	45.06	0.05	54.89	256.03	0.	611.02												100.000	
2.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	3.1765E 00	261.15	38.86	0.01	61.14	249.95	0.	611.10												100.000	
2.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	2.3877E 00	265.98	34.02	0.00	65.98	245.13	0.	611.11												100.000	
2.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	1.9031E 00	269.72	30.28	0.00	69.72	241.39	0.	611.11												100.000	
4.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	8.9364E 09	354.68	22.66	77.34	0.00	1.74	0.	456.43												100.000	
4.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	3.0127E 06	348.84	25.56	74.41	0.03	13.45	0.	462.30												100.000	
4.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	1.1581E 04	330.07	34.67	64.73	0.60	51.57	0.	481.64												100.000	
4.0000	1000.00	4.9010E-02	3.7523E 00	6.4774E 01	2.058CE 02	295.58	49.41	44.99	5.59	125.54	0.	521.12												100.000	
4.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	1.3794E 01	259.37	58.01	17.38	24.62	216.99	0.	576.36												100.000	
4.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	7.4849E 00	259.37	58.01	17.38	24.62	216.99	0.	576.36												100.000	

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TABLE F-19B

PRODUCT COMPOSITIONS FOR HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FFED - C9H20 (100 MOLE % BASIS), STEAM/C RATIO, 4.0

ELEMENTAL COMPOSITION				EQUILIBRIUM PRODUCT COMPOSITIONS																		
C(ATOMS)	H(ATOMS)	C(ATMOS)	N2(MOLS)	H2O			CO2			CH4			CO			H2			N2			TOTAL
100.0	1022.22	400.00	0.	MOL	PC	MOL	PC	MOL	PC	MOL	PC	MOL	PC	MOL	PC	MOL	PC	MOL	PC	MOL	PC	
4.0000	1400.00	6.3697E-01	1.2081E-00	2.7306E-01	3.9330E-01	249.34	52.77	2.11	45.12	257.56	0.	606.89	41.084	8.695	0.347	7.435	42.438	0.	100.000			
4.0000	1600.00	8.2139E-02	8.2439E-01	4.0069E-02	2.2945E-01	255.13	45.06	0.19	54.76	255.61	0.	610.74	41.774	7.377	0.031	8.966	41.852	0.	100.000			
4.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	1.5890E-00	261.17	38.86	0.02	61.12	249.90	0.	611.06	42.740	6.359	0.004	10.032	40.896	0.	100.000			
4.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	1.1935E-00	265.99	44.02	0.00	65.98	245.12	0.	611.10	43.526	5.567	0.001	10.796	40.111	0.	100.000			
4.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	9.5155E-01	269.72	30.28	0.00	69.72	241.39	0.	611.11	44.137	4.955	0.000	11.409	39.500	0.	100.000			
6.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	8.9462E-09	355.05	22.47	77.53	0.00	1.42	0.	456.27	77.771	22.58	77.42	0.000	0.312	0.	100.000			
6.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	3.0910E-06	351.60	24.19	75.79	0.02	11.07	0.	461.11	75.911	24.97	75.00	0.003	2.432	0.	100.000			
6.0000	800.00	2.6585E-04	9.0223E-03	3.7690E-03	1.1886E-04	334.21	32.66	66.87	0.47	43.17	0.	477.37	70.010	6.842	14.008	0.098	9.042	0.	100.000			
6.0000	1000.00	4.9018E-02	3.7523E-00	6.4774E-01	2.0876E-02	303.92	45.88	49.82	4.33	107.60	0.	511.52	59.415	8.969	9.735	0.846	21.035	0.	100.000			
6.0000	1200.00	2.6875E-00	1.9714E-03	3.0042E-00	1.2426E-01	268.31	55.60	23.91	20.50	194.99	0.	563.30	47.632	9.870	4.244	3.638	34.616	0.	100.000			
6.0000	1400.00	6.3697E-01	1.2081E-00	2.7306E-01	2.8123E-00	251.75	52.48	4.23	43.29	250.91	0.	602.66	41.773	8.708	0.701	7.184	41.634	0.	100.000			
6.0000	1600.00	8.2139E-02	8.2439E-01	4.0069E-02	1.5403E-00	255.37	45.04	0.42	54.54	254.91	0.	610.28	41.845	7.381	0.068	8.937	41.769	0.	100.000			
6.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	1.0602E-00	261.19	38.86	0.05	61.09	249.81	0.	611.01	42.740	6.359	0.008	9.998	40.885	0.	100.000			
6.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	7.9606E-01	265.99	34.02	0.01	65.97	245.10	0.	611.09	43.527	5.567	0.001	10.796	40.109	0.	100.000			
6.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	6.3441E-01	269.72	30.28	0.00	69.72	241.38	0.	611.11	44.137	4.955	0.000	11.409	39.499	0.	100.000			
12.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	8.9462E-09	355.05	22.47	77.53	0.00	1.01	0.	456.06	77.852	4.928	16.999	0.000	0.221	0.	100.000			
12.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	3.0910E-06	351.60	24.19	75.79	0.02	7.92	0.	459.52	76.515	5.264	16.494	0.004	1.723	0.	100.000			
12.0000	800.00	2.6585E-04	9.0223E-03	3.7690E-03	1.2366E-04	339.90	29.89	69.80	0.31	31.61	0.	471.52	72.087	6.340	14.803	0.065	6.705	0.	100.000			
12.0000	1000.00	4.9018E-02	3.7523E-00	6.4774E-01	2.1656E-02	316.17	40.52	56.69	2.79	81.56	0.	497.73	63.522	8.142	11.350	0.560	16.387	0.	100.000			
12.0000	1200.00	2.6875E-00	1.9714E-00	3.0042E-00	1.1379E-01	284.33	50.74	35.08	14.18	156.62	0.	540.95	52.562	9.380	6.484	2.621	28.953	0.	100.000			
12.0000	1400.00	6.3697E-01	1.2081E-00	2.7306E-01	1.7995E-01	259.89	51.35	11.24	37.41	228.74	0.	588.63	44.152	8.724	1.910	6.355	38.860	0.	100.000			
12.0000	1600.00	8.2139E-02	8.2439E-01	4.0069E-02	7.9759E-01	256.59	44.98	1.57	53.45	251.38	0.	607.97	42.204	7.398	0.258	8.792	41.347	0.	100.000			
12.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	5.3247E-01	261.35	38.86	0.21	60.94	249.35	0.	610.70	42.795	6.362	0.034	9.979	40.830	0.	100.000			
12.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	3.9833E-01	266.02	34.02	0.04	65.95	245.02	0.	611.04	43.535	5.567	0.006	10.792	40.099	0.	100.000			
12.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	3.1726E-01	269.73	30.28	0.01	69.71	241.36	0.	611.09	44.139	4.955	0.001	11.408	39.497	0.	100.000			

TABLE F-20A

PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - C9H20 (100 MOL % BASIS), STEAM/C RATIO, 5.0

P(ATM)	T(CEG F)	ELEMENTAL COMPOSITION			RT	EQUILIBRIUM PRODUCT COMPOSITIONS										TOTAL MOLS MOL PC
		C(ATM%)	H(ATM%)	N2(ATM%)		H2O MOLS MOL PC	CO MOLS MOL PC	CH4 MOLS MOL PC	H2 MOLS MOL PC	N2 MOLS MOL PC	CO2 MOLS MOL PC	CH3 MOLS MOL PC	CO MOLS MOL PC	CH4 MOLS MOL PC	CH3 MOLS MOL PC	
1.0000	600.00	7.9414E-12	2.0711E-02	4.0007E-09	1.1309E-11	453.40 81.296	23.30 4.178	76.70 13.752	0.00 0.000	4.31 0.773	0. 0.	557.71 100.000	0. 0.	0. 0.	0. 0.	0. 0.
1.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	3.6117E-06	439.72 76.948	30.10 5.268	69.83 12.219	0.07 0.012	31.73 5.553	0. 0.	571.46 100.000	0. 0.	0. 0.	0. 0.	0. 0.
1.0000	800.00	2.6585E-04	9.0223E-02	3.7690E-03	1.3537E-04	401.17 65.612	48.67 7.961	49.84 8.152	1.48 0.243	110.26 18.033	0. 0.	611.42 100.000	0. 0.	0. 0.	0. 0.	0. 0.
1.0000	1000.00	4.9018E-02	3.7523E-00	6.4774E-01	3.2169E-02	348.31 51.609	69.80 10.342	18.10 2.687	12.10 1.793	226.59 33.574	0. 0.	674.90 100.000	0. 0.	0. 0.	0. 0.	0. 0.
1.0000	1200.00	2.6875E-00	1.9714E-02	3.0042E-00	5.7321E-01	332.03 46.874	69.35 9.750	1.38 0.195	29.27 4.133	276.32 39.0.9	0. 0.	708.35 100.000	0. 0.	0. 0.	0. 0.	0. 0.
1.0000	1400.00	6.3697E-01	1.2081E-02	2.7306E-01	2.7102E-01	339.88 47.806	60.19 8.466	0.07 0.010	39.74 5.589	271.08 38.129	0. 0.	710.97 100.000	0. 0.	0. 0.	0. 0.	0. 0.
1.0000	1600.00	8.2139E-02	8.2439E-01	4.0069E-02	1.6188E-01	347.87 48.920	52.14 7.332	0.01 0.001	47.86 6.730	263.23 37.017	0. 0.	711.10 100.000	0. 0.	0. 0.	0. 0.	0. 0.
1.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	1.0983E-01	354.36 49.832	45.64 6.418	0.00 0.000	54.36 7.644	256.75 36.105	0. 0.	711.11 100.000	0. 0.	0. 0.	0. 0.	0. 0.
1.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	8.1095E-02	359.55 50.562	40.45 5.688	0.00 0.000	59.55 8.375	251.56 35.375	0. 0.	711.11 100.000	0. 0.	0. 0.	0. 0.	0. 0.
1.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	6.3807E-02	363.65 51.138	36.35 5.112	0.00 0.000	63.65 8.951	247.46 34.799	0. 0.	711.11 100.000	0. 0.	0. 0.	0. 0.	0. 0.
2.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	1.1338E-10	454.02 81.499	22.99 4.126	77.01 13.824	0.00 0.000	3.06 0.550	0. 0.	557.09 100.000	0. 0.	0. 0.	0. 0.	0. 0.
2.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	3.7276E-06	444.05 78.301	27.95 4.929	72.06 12.696	0.05 0.008	23.06 4.066	0. 0.	567.11 100.000	0. 0.	0. 0.	0. 0.	0. 0.
2.0000	800.00	2.6585E-04	9.0223E-02	3.7690E-03	1.4045E-04	414.18 69.276	42.43 7.097	56.62 9.470	0.95 0.159	83.69 13.998	0. 0.	597.88 100.000	0. 0.	0. 0.	0. 0.	0. 0.
2.0000	1000.00	4.9018E-02	3.7523E-02	6.4774E-01	2.8269E-02	366.39 56.089	62.56 9.576	28.94 4.431	8.50 1.301	186.84 28.602	0. 0.	653.22 100.000	0. 0.	0. 0.	0. 0.	0. 0.
2.0000	1200.00	2.6875E-00	1.9714E-02	3.0042E-00	3.2145E-01	336.44 47.930	68.14 9.707	4.58 0.653	27.28 3.886	265.50 37.824	0. 0.	701.94 100.000	0. 0.	0. 0.	0. 0.	0. 0.
2.0000	1400.00	6.3697E-01	1.2081E-02	2.7306E-01	1.3644E-01	340.14 47.871	60.14 8.464	0.29 0.040	39.57 5.569	270.39 38.055	0. 0.	710.54 100.000	0. 0.	0. 0.	0. 0.	0. 0.
2.0000	1600.00	8.2139E-02	8.2439E-01	4.0069E-02	8.0986E-02	347.89 48.925	52.14 7.332	0.02 0.003	47.84 6.728	263.17 37.011	0. 0.	711.06 100.000	0. 0.	0. 0.	0. 0.	0. 0.
2.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	5.4921E-02	354.36 49.833	45.64 6.418	0.00 0.000	54.36 7.644	256.74 36.105	0. 0.	711.10 100.000	0. 0.	0. 0.	0. 0.	0. 0.
2.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	4.0548E-02	359.55 50.563	40.45 5.688	0.00 0.000	59.55 8.375	251.55 35.375	0. 0.	711.11 100.000	0. 0.	0. 0.	0. 0.	0. 0.
2.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	3.1904E-02	363.65 51.138	36.35 5.112	0.00 0.000	63.65 8.951	247.46 34.799	0. 0.	711.11 100.000	0. 0.	0. 0.	0. 0.	0. 0.
4.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	1.1268E-10	454.47 81.645	22.77 4.090	77.23 13.875	0.00 0.000	2.17 0.390	0. 0.	556.64 100.000	0. 0.	0. 0.	0. 0.	0. 0.
4.0000	600.00	2.1990E-07	3.1475E-01	1.0438E-06	3.8241E-06	447.25 79.314	26.36 4.675	73.61 13.053	0.03 0.006	16.67 2.953	0. 0.	563.90 100.000	0. 0.	0. 0.	0. 0.	0. 0.
4.0000	800.00	2.6585E-04	9.0223E-02	3.7690E-03	1.4652E-04	424.53 72.298	37.43 6.374	61.96 10.552	0.61 0.104	62.67 10.672	0. 0.	587.19 100.000	0. 0.	0. 0.	0. 0.	0. 0.
4.0000	1000.00	4.9018E-02	3.7523E-02	6.4774E-01	2.7125E-02	384.21 60.739	55.06 8.704	39.27 6.209	5.67 0.896	148.35 23.452	0. 0.	632.56 100.000	0. 0.	0. 0.	0. 0.	0. 0.
4.0000	1200.00	2.6875E-00	1.9714E-02	3.0042E-00	2.1145E-01	346.50 50.389	65.24 9.487	11.73 1.706	23.03 3.349	241.14 35.068	0. 0.	687.64 100.000	0. 0.	0. 0.	0. 0.	0. 0.

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TABLE F-20B

PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - C9H20 (100 MOLE % BASIS), STEAM/C RATIO, 5.0

ELEMENTAL COMPOSITION			EQUILIBRIUM PRODUCT COMPOSITIONS											
C (ATMOS)	H (ATMOS)	C (ATMOS)	N2(MOLE %)		RT	H2O MOLES MOL PC	CO2 MOLES MOL PC	CH4 MOLES MOL PC	CO MOLES MOL PC	H2 MOLES MOL PC	N2 MOLES MOL PC	TOTAL MOLES MOL PC		
160.00	1222.22	500.00	0.											
4.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	7.0032E 00	341.14 48.122	59.95 8.457	1.10 0.155	38.95 5.494	267.78 37.772	0. 0.	708.92 100.000		
4.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	4.0582E 00	347.97 48.947	52.12 7.332	0.10 0.014	47.78 6.721	262.95 36.987	0. 0.	710.92 100.000		
4.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	2.7468E 00	354.37 49.835	45.64 6.418	0.01 0.002	54.35 7.643	256.71 36.102	0. 0.	711.69 100.000		
4.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	2.0275E 00	359.56 50.563	40.45 5.688	0.00 0.004	59.55 8.375	251.55 35.374	0. 0.	711.11 100.000		
4.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	1.5952E 00	363.65 51.139	36.35 5.112	0.00 0.001	63.65 8.951	247.46 34.799	0. 0.	711.11 100.000		
6.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	1.1313E 10	454.67 81.7C9	22.67 4.073	77.33 13.898	0.00 0.000	1.78 0.319	0. 0.	556.44 100.000		
6.0000	600.00	2.199CE-07	3.1479E 01	1.0438E 06	3.8704E 06	448.7C 79.779	25.64 4.558	74.34 13.218	0.02 0.004	13.73 2.441	0. 0.	562.43 100.000		
6.0000	800.00	2.6585E-04	9.0223E 00	3.769CE 03	1.5019E 04	429.48 73.780	35.02 6.016	64.5G 11.081	0.48 0.082	52.63 9.041	0. 0.	582.11 100.000		
6.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	2.7105E 02	393.75 63.327	50.92 8.189	44.67 7.184	4.41 0.710	128.02 20.550	0. 0.	621.77 100.000		
6.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	1.8051E 01	354.98 52.520	62.62 9.265	17.61 2.605	19.77 2.925	220.92 32.685	0. 0.	675.90 100.000		
6.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	4.8581E 00	342.64 48.499	59.66 8.445	2.31 0.327	38.03 5.383	263.85 37.346	0. 0.	706.49 100.000		
6.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	2.7153E 00	348.11 48.982	52.11 7.332	0.22 0.030	47.68 6.709	262.57 36.947	0. 0.	710.68 100.000		
6.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	1.832CE 00	354.39 49.840	45.64 6.418	0.03 0.004	54.33 7.641	256.67 36.097	0. 0.	711.06 100.000		
6.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	1.3518E 00	359.56 50.564	40.45 5.688	0.00 0.001	59.55 8.374	251.54 35.374	0. 0.	711.10 100.000		
6.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	1.0635E 00	363.65 51.139	36.35 5.112	0.00 0.001	63.65 8.951	247.46 34.799	0. 0.	711.11 100.000		
12.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	1.1502E 10	454.93 81.794	22.54 4.052	77.46 13.928	0.00 0.000	1.26 0.226	0. 0.	556.18 100.000		
12.0000	600.00	2.199CE-07	3.1479E 01	1.0438E 06	3.9363E 06	450.65 80.403	24.67 4.401	75.31 13.437	0.02 0.003	9.84 1.755	0. 0.	560.48 100.000		
12.0000	800.00	2.6585E-04	9.0223E 00	3.769CE 03	1.5626E 04	436.34 75.875	31.67 5.568	68.01 11.827	0.31 0.054	38.74 6.736	0. 0.	575.08 100.000		
12.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	2.7669E 02	408.00 67.331	44.57 7.356	52.57 8.676	2.85 0.471	97.96 16.166	0. 0.	605.96 100.000		
12.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	1.549CE 01	371.70 56.871	57.07 8.732	28.76 4.461	14.17 2.167	181.89 27.829	0. 0.	653.58 100.000		
12.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	2.8558E 00	348.59 50.014	58.46 8.388	7.06 1.012	34.48 4.947	248.41 35.639	0. 0.	697.60 100.000		
12.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	1.3835E 02	348.81 49.167	52.02 7.332	0.83 1.117	47.15 6.646	260.63 36.737	0. 0.	709.44 100.000		
12.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	9.1816E-01	354.48 49.864	45.63 6.419	0.11 0.015	54.26 7.633	256.42 36.070	0. 0.	710.89 100.000		
12.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	6.7615E-01	359.57 50.568	40.45 5.688	0.02 0.003	59.54 8.373	251.50 35.369	0. 0.	711.07 100.000		
12.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	5.3175E-01	363.65 51.139	36.35 5.112	0.00 0.001	63.64 8.950	247.45 34.798	0. 0.	711.10 100.000		

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RE 647680

TABLE F-21

PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - CNH₂N (100 MOLE % BASIS), STEAM/C RATIO, 1.0

ELEMENTAL COMPOSITION				EQUILIBRIUM PRODUCT COMPOSITIONS										TOTAL MOLES MOL PC
C(ATOMS)	H(ATOMS)	O(ATOMS)	N2(MOLES)	CONDITIONS AND EQUILIBRIUM CONSTANTS		RT	H2O MOLES MOL PC	CO2 MOLES MOL PC	CH4 MOLES MOL PC	CO MOLES MOL PC	H2 MOLES MOL PC	N2 MOLES MOL PC		
100.00	400.00	100.00	0.	P(ATM)	T(DEG F)	XR	Ks	Kc						
1.0000	1600.00	8.2139E-02	8.2439E-01	4.0069E-02	3.4180E-02		2.57 0.877	1.06 0.362	3.63 1.239	95.31 32.558	190.18 64.964	0. 0.	292.74 100.00	
CONDITIONS LEAD TO CARBON FORMATION.														
1.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	9.1257E-03		0.98 0.328	0.30 0.100	1.27 0.428	98.43 33.091	196.48 66.954	0. 0.	297.45 100.00	
1.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	3.0177E-03		0.42 0.140	0.10 0.033	5.52 0.174	99.38 33.242	198.54 66.411	0. 0.	298.96 100.00	
1.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	1.1838E-03		0.20 0.067	0.04 0.013	0.24 0.081	99.72 33.293	199.32 66.545	0. 0.	299.52 100.00	
2.0000	1600.00	8.2139E-02	8.2439E-01	4.0069E-02	3.4132E-02		4.79 1.673	1.98 0.693	6.78 2.365	91.24 31.852	181.66 63.417	0. 0.	286.45 100.00	
CONDITIONS LEAD TO CARBON FORMATION.														
2.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	9.1150E-03		1.90 0.645	0.58 0.197	2.48 0.841	96.94 32.856	193.13 65.461	0. 0.	295.04 100.00	
2.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	3.0157E-03		0.83 0.278	0.20 0.066	1.03 0.345	98.78 33.152	197.12 66.158	0. 0.	297.95 100.00	
2.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	1.1834E-03		0.40 0.135	0.08 0.026	0.48 0.161	99.44 33.254	198.64 66.425	0. 0.	299.04 100.00	
4.0000	1600.00	8.2139E-02	8.2439E-01	4.0069E-02	3.4044E-02		8.47 3.069	3.52 1.276	11.99 4.345	84.49 30.639	167.54 60.701	0. 0.	276.01 100.00	
CONDITIONS LEAD TO CARBON FORMATION.														
4.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	9.0945E-03		3.62 1.247	1.11 0.382	4.73 1.629	94.16 32.408	186.91 64.334	0. 0.	290.54 100.00	
4.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	3.0118E-03		1.62 0.549	0.39 0.131	2.01 0.680	97.60 32.976	194.35 65.664	0. 0.	295.97 100.00	
4.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	1.1825E-03		0.80 0.267	0.16 0.052	0.95 0.319	98.89 33.175	197.30 66.187	0. 0.	298.10 100.00	
6.0000	1600.00	8.2139E-02	8.2439E-01	4.0069E-02	3.3966E-02		11.41 4.263	4.76 1.778	16.17 6.042	79.07 29.541	156.25 58.376	0. 0.	267.66 100.00	
CONDITIONS LEAD TO CARBON FORMATION.														
6.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	9.0750E-03		5.19 1.812	1.60 0.557	6.78 2.369	91.62 31.987	181.24 63.276	0. 0.	286.43 100.00	
6.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	3.0080E-03		2.39 0.812	0.57 0.194	2.96 1.006	96.47 32.804	191.69 65.184	0. 0.	294.08 100.00	
6.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	1.1817E-03		1.18 0.398	0.23 0.078	1.41 0.476	98.36 33.097	195.99 65.951	0. 0.	297.17 100.00	
12.0000	1600.00	8.2139E-02	8.2439E-01	4.0069E-02	3.3773E-02		17.60 7.039	7.41 2.963	25.00 10.002	67.59 27.037	132.4 52.960	0. 0.	249.99 100.00	
CONDITIONS LEAD TO CARBON FORMATION.														
12.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	9.0211E-03		9.16 3.319	2.84 1.030	12.00 4.349	85.15 30.853	166.83 60.448	0. 0.	275.99 100.00	
12.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	2.9970E-03		4.51 1.561	1.08 0.376	5.59 1.936	93.32 32.312	184.31 63.815	0. 0.	288.82 100.00	
12.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	1.1792E-03		2.30 0.781	0.45 0.153	2.75 0.934	96.80 32.869	192.20 65.263	0. 0.	294.51 100.00	

CALIFORNIA RESEARCH
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RE 647681

TABLE F-22A

PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - CNH₂N (100 MOL C BASIS), STEAM/C RATIO, 2.0

P(ATM)	T(DEG F)	ELEMENTAL COMPOSITION				RT	EQUILIBRIUM PRODUCT COMPOSITIONS								TOTAL MOL PC	
		C(ATOMS)	H(ATOMS)	O(ATOMS)	N2(MOLS)		H2O MOLS MOL PC	CO2 MOLS MOL PC	CH4 MOLS MOL PC	CO MOLS MOL PC	H2 MOLS MOL PC	N2 MOLS MOL PC				
1.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	3.6115E-09	149.19 59.486	25.40 10.128	74.60 29.743	0.00 0.001	1.61 0.643	0. 0.	250.81 100.000				
CONDITIONS LEAD TO CARBON FORMATION.																
1.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	1.2062E-06	143.81 56.117	28.06 10.948	71.87 28.044	0.08 0.030	12.46 4.861	0. 0.	256.27 100.000				
1.0000	800.00	2.6585E-04	9.0223E-00	3.7690E-03	4.4545E-03	126.97 46.252	35.77 13.031	62.74 22.856	1.48 0.541	47.55 17.320	0. 0.	274.52 100.000				
1.0000	1000.00	4.9018E-02	3.7523E-00	6.4774E-01	7.5300E-01	99.20 31.562	43.65 13.889	42.85 13.634	13.50 4.295	115.10 36.621	0. 0.	314.30 100.000				
1.0000	1200.00	2.6875E-00	1.9714E-00	3.0042E-00	5.7648E-00	75.94 20.341	37.38 10.013	13.33 3.570	49.29 13.202	197.40 52.874	0. 0.	373.35 100.000				
1.0000	1400.00	6.3697E-01	1.2081E-00	2.7306E-01	2.2052E-00	73.16 18.391	27.93 7.020	1.09 0.274	70.98 17.843	224.65 56.472	0. 0.	397.82 100.000				
1.0000	1600.00	8.2139E-02	8.2439E-01	4.0069E-02	1.4872E-00	77.72 19.437	22.37 5.594	0.08 0.021	77.55 19.395	222.12 55.553	0. 0.	399.83 100.000				
1.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	1.1140E-00	81.51 20.379	18.50 4.624	0.01 0.002	81.49 20.374	218.47 54.620	0. 0.	399.98 100.000				
1.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	8.8132E-01	84.33 21.083	15.67 3.917	0.00 0.000	84.33 21.083	215.66 53.916	0. 0.	400.00 100.000				
1.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	7.2785E-01	86.41 21.603	13.59 3.397	0.00 0.000	86.41 21.603	213.59 53.397	0. 0.	400.00 100.000				
2.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	3.6119E-09	149.43 59.635	25.28 10.091	74.71 29.817	0.00 0.000	1.14 0.456	0. 0.	250.57 100.000				
CONDITIONS LEAD TO CARBON FORMATION.																
2.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	1.2325E-06	145.56 57.198	27.19 10.685	72.75 28.588	0.05 0.021	8.93 3.508	0. 0.	254.49 100.000				
2.0000	800.00	2.6585E-04	9.0223E-00	3.7690E-03	4.7312E-03	132.93 49.593	33.05 12.331	65.98 24.616	0.97 0.361	35.11 13.099	0. 0.	268.04 100.000				
2.0000	1000.00	4.9018E-02	3.7523E-00	6.4774E-01	7.9625E-01	110.01 36.829	40.63 13.601	50.64 16.953	8.73 2.922	88.70 29.694	0. 0.	298.71 100.000				
2.0000	1200.00	2.6875E-00	1.9714E-00	3.0042E-00	4.7677E-00	85.80 24.388	38.30 10.888	24.10 6.851	37.59 10.686	166.00 47.186	0. 0.	351.80 100.000				
2.0000	1400.00	6.3697E-01	1.2081E-00	2.7306E-01	1.2128E-00	75.33 19.194	28.42 7.242	3.76 0.957	67.82 17.279	217.15 55.327	0. 0.	392.48 100.000				
2.0000	1600.00	8.2139E-02	8.2439E-01	4.0069E-02	7.4972E-01	77.92 19.511	22.41 5.612	0.33 0.082	77.26 19.347	221.43 55.448	0. 0.	399.34 100.000				
2.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	5.5753E-01	81.54 20.388	18.50 4.626	0.04 0.010	81.46 20.369	218.39 54.607	0. 0.	399.92 100.000				
2.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	4.4072E-01	84.34 21.085	15.67 3.917	0.01 0.002	84.32 21.082	215.65 53.914	0. 0.	399.99 100.000				
2.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	3.6393E-01	86.41 21.604	13.59 3.397	0.00 0.000	86.41 21.603	213.58 53.396	0. 0.	400.00 100.000				
4.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	3.6224E-09	149.60 59.742	25.20 10.064	74.80 29.871	0.00 0.000	0.81 0.323	0. 0.	250.40 100.000				
4.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	1.2524E-06	146.83 57.989	26.57 10.492	73.40 28.987	0.04 0.014	6.38 2.518	0. 0.	253.21 100.000				
4.0000	800.00	2.6585E-04	9.0223E-00	3.7690E-03	4.9668E-03	137.49 52.246	30.94 11.756	68.42 26.001	0.64 0.243	25.67 9.754	0. 0.	263.15 100.000				
4.0000	1000.00	4.9018E-02	3.7523E-00	6.4774E-01	8.4763E-01	119.26 41.645	37.55 13.114	56.81 19.839	5.63 1.967	67.11 23.435	0. 0.	286.37 100.000				
4.0000	1200.00	2.6875E-00	1.9714E-00	3.0042E-00	4.4614E-00	96.91 29.396	38.25 11.603	35.16 10.666	26.58 8.064	132.76 40.271	0. 0.	329.67 100.000				

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TABLE F-22B

PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - CNH2N (100 MOLE C BASIS), STEAM/C RATIO, 2.0

ELEMENTAL COMPOSITION				EQUILIBRIUM PRODUCT COMPOSITIONS											
C(ATOMS)	H(ATOMS)	O(ATOMS)	N2(MOLS)	CONDITIONS AND EQUILIBRIUM CONSTANTS				RT	H2O	CO2	CH4	CO	H2	N2	TOTAL
100.0	600.00	200.00	0.	P(ATM)	T(DEG F)	KR	KS	KC	MOLS MOL PC						
4.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	7.7239E-01	80.70	29.53	10.23	60.23	198.84	0.	379.54			
						21.262	7.782	2.696	15.870	52.390	0.	100.000			
4.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	3.8667E-01	78.67	22.58	1.25	76.17	218.82	0.	397.50			
						19.792	5.680	0.315	19.163	55.050	0.	100.000			
4.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	2.7980E-01	81.63	18.52	0.15	81.33	218.06	0.	399.70			
						20.423	4.634	0.038	20.347	54.557	0.	100.000			
4.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	2.2049E-01	84.35	15.67	0.03	84.30	215.60	0.	399.45			
						21.091	3.919	0.006	21.078	53.906	0.	100.000			
4.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	1.8199E-01	86.42	13.59	0.01	86.41	213.57	0.	399.99			
						21.605	3.397	0.001	21.602	53.394	0.	100.000			
6.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	3.6291E 09	149.67	25.16	74.83	0.00	0.66	0.	250.33			
CONDITIONS LEAD TO CARBON FORMATION.						59.789	10.053	29.894	0.000	0.264	0.	100.000			
6.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	1.2614E 06	147.40	26.28	73.69	0.03	5.23	0.	252.63			
						58.347	10.405	29.167	0.012	2.070	0.	100.000			
6.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	5.0849E 03	139.61	29.94	69.55	0.51	21.29	0.	260.90			
						53.511	11.477	26.659	0.194	8.159	0.	100.000			
6.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	8.7835E 01	123.88	35.88	59.75	4.37	56.62	0.	280.49			
						44.164	12.791	21.303	1.558	20.184	0.	100.000			
6.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	4.5132E 00	103.30	37.73	41.03	21.24	114.63	0.	317.93			
						32.492	11.867	12.906	6.680	36.055	0.	100.000			
6.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	6.4693E-01	85.55	30.39	15.93	53.68	182.59	0.	368.14			
						23.237	8.254	4.328	14.582	49.599	0.	100.000			
6.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	2.6998E-01	79.79	22.82	2.61	74.57	214.98	0.	394.78			
						20.212	5.780	0.661	18.889	54.457	0.	100.000			
6.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	1.8767E-01	81.79	18.55	0.34	81.11	217.53	0.	399.32			
						20.482	4.646	0.085	20.312	54.476	0.	100.000			
6.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	1.4714E-01	84.38	15.68	0.06	84.21	215.51	0.	399.89			
						21.101	3.920	0.014	21.073	53.892	0.	100.000			
6.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	1.2135E-01	86.42	13.59	0.01	86.40	213.55	0.	399.98			
						21.607	3.397	0.003	21.601	53.391	0.	100.000			
12.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	3.5992E 09	149.77	25.12	74.88	0.00	0.47	0.	250.23			
CONDITIONS LEAD TO CARBON FORMATION.						59.851	10.037	29.925	0.000	0.187	0.	100.000			
12.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	1.2733E 06	148.15	25.91	74.07	0.02	3.72	0.	251.87			
						58.820	10.289	29.406	0.008	1.477	0.	100.000			
12.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	5.2540E 03	142.48	28.59	71.07	0.34	15.38	0.	257.86			
						55.256	11.087	27.562	0.133	5.963	0.	100.000			
12.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	9.2868E 01	130.47	33.34	63.81	2.85	41.92	0.	272.39			
						47.898	12.239	23.425	1.048	15.389	0.	100.000			
12.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	4.5155E 00	113.35	36.23	49.59	14.18	87.48	0.	300.83			
						37.680	12.044	16.483	4.715	29.078	0.	100.000			
12.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	5.4124E-01	95.64	31.66	27.30	41.03	149.75	0.	345.39			
						27.691	9.167	7.905	11.880	43.357	0.	100.000			
12.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	1.6173E-01	84.07	23.70	7.78	68.52	200.37	0.	384.45			
						21.869	6.165	2.023	17.823	52.119	0.	100.000			
12.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	9.6796E-02	82.58	18.71	1.29	80.00	214.84	0.	397.42			
						20.779	4.707	0.324	20.131	54.059	0.	100.000			
12.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	7.3964E-02	84.52	15.70	0.22	84.07	215.03	0.	399.55			
						21.154	3.930	0.056	21.042	53.818	0.	100.000			
12.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	6.0746E-02	86.45	13.59	0.05	86.36	213.45	0.	399.90			
						21.619	3.399	0.012	21.595	53.375	0.	100.000			

TABLE F-23A

PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - CNH₂N (100% MOL C BASIS), STEAM/C RATIO, 3.0

P(ATHM)	T(DEG F)	ELEMENTAL COMPOSITION			EQUILIBRIUM PRODUCT COMPOSITIONS									
		C(ATOMS) 100.00	H(ATOMS) 800.00	O(ATOMS) 300.00	N2(MOLS) 0.	H2O MOLS MOL PC	CO2 MOLS MOL PC	CH4 MOLS MOL PC	CO MOLS MOL PC	H2 MOLS MOL PC	N2 MOLS MOL PC	TOTAL MOLS MOL PC		
1.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	5.9997E 09	248.77 70.829	25.61 7.293	74.39 21.179	0.00 0.000	2.46 0.700	0. 0.	351.23 100.000		
1.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	1.9861E 06	240.67 66.966	29.63 8.243	70.30 19.561	0.07 0.020	18.72 5.210	0. 0.	359.40 100.000		
1.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	7.3882E 03	216.07 56.062	41.23 10.699	57.30 14.867	1.47 0.381	69.34 17.991	0. 0.	385.40 100.000		
1.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	1.3877E 02	177.08 40.609	54.89 12.589	31.97 7.332	13.13 3.012	158.98 36.458	0. 0.	436.05 100.000		
1.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	1.5006E 01	152.67 31.231	52.91 10.823	5.58 1.141	41.52 8.493	236.17 48.313	0. 0.	488.84 100.000		
1.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	6.9525E 00	156.65 31.370	43.67 8.746	0.32 0.064	56.01 11.216	242.71 48.604	0. 0.	499.36 100.000		
1.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	4.4872E 00	163.68 32.740	36.34 7.269	0.02 0.005	63.63 12.728	236.27 47.258	0. 0.	499.95 100.000		
1.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	3.2230E 00	169.17 33.034	30.83 6.167	0.00 0.001	69.16 13.833	230.83 46.166	0. 0.	499.99 100.000		
1.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	2.4773E 00	173.35 34.669	26.65 5.331	0.00 0.000	73.35 14.669	226.65 45.331	0. 0.	500.00 100.000		
1.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	2.0059E 00	176.51 35.303	23.49 4.697	0.00 0.000	76.51 15.303	223.49 44.697	0. 0.	500.00 100.000		
2.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	6.0571E 09	249.13 71.003	25.43 7.249	74.56 21.251	0.00 0.000	1.74 0.497	0. 0.	350.87 100.000		
2.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	2.0339E 06	243.29 68.193	28.33 7.941	71.62 20.075	0.05 0.014	13.47 3.777	0. 0.	356.76 100.000		
2.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	7.7839E 03	224.64 59.697	37.20 9.887	61.85 16.435	0.95 0.252	51.66 13.729	0. 0.	376.31 100.000		
2.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	1.3841E 02	191.76 45.997	49.79 11.943	41.55 9.966	8.66 2.077	125.14 30.017	0. 0.	416.90 100.000		
2.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	1.0303E 01	161.49 34.138	51.98 10.989	13.47 2.848	34.54 7.302	211.57 44.723	0. 0.	473.05 100.000		
2.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	3.5813E 00	157.54 31.663	43.69 8.780	1.23 0.246	55.09 11.072	240.01 48.238	0. 0.	497.55 100.000		
2.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	2.2488E 00	163.75 32.764	36.35 7.272	0.10 0.020	63.55 12.716	236.05 47.228	0. 0.	499.80 100.000		
2.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	1.6119E 00	169.18 33.037	30.84 6.167	0.01 0.002	69.15 13.831	230.80 46.162	0. 0.	499.98 100.000		
2.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	1.2387E 00	173.35 34.670	26.65 5.331	0.00 0.000	73.34 14.669	226.65 45.330	0. 0.	500.00 100.000		
2.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	1.0030E 00	176.51 35.303	23.49 4.697	0.00 0.000	76.51 15.303	223.49 44.697	0. 0.	500.00 100.000		
4.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	6.0300E 09	249.38 71.127	25.31 7.218	74.69 21.303	0.00 0.000	1.23 0.352	0. 0.	350.62 100.000		
4.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	2.0713E 06	245.19 69.098	27.39 7.718	72.58 20.454	0.03 0.010	9.65 2.720	0. 0.	354.84 100.000		
4.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	8.1506E 03	231.28 62.619	34.05 9.219	65.33 17.688	0.62 0.168	38.06 10.305	0. 0.	369.34 100.000		
4.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	1.4259E 02	204.72 51.065	44.83 11.184	49.55 12.360	5.61 1.400	96.18 23.991	0. 0.	400.90 100.000		
4.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	8.4595E 03	174.19 38.569	49.99 11.068	24.18 5.354	25.83 5.719	177.45 39.289	0. 0.	451.64 100.000		

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TABLE F-23B

PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - CNH2N (100 MOL C BASIS), STEAM/C RATIO, 3.0

ELEMENTAL COMPOSITION				EQUILIBRIUM PRODUCT COMPOSITIONS											
C(ATOMS)	H(ATOMS)	O(ATOMS)	N2(MOLS)	CONDITIONS AND EQUILIBRIUM CONSTANTS			RT	H2O MOLS MOL PC	CO2 MOLS MOL PC	CH4 MOLS MOL PC	CO MOLS MOL PC	H2 MOLS MOL PC	N2 MOLS MOL PC	TOTAL MOLS MOL PC	
100.00	800.00	300.00	0.	P(ATM)	T(DEG F)	KR	KS	KC							
4.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	1.9774E 00	160.46	43.71	4.17	52.12	231.19	0.	491.66			
						32.637	8.890	0.848	10.601	47.023	0.	100.000			
4.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	1.1346E 00	164.03	36.36	0.39	63.24	235.19	0.	499.22			
						32.857	7.284	0.079	12.669	47.111	0.	100.000			
4.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	8.0682E-01	169.21	30.84	0.05	69.11	230.70	0.	499.91			
						33.848	6.169	0.009	13.826	46.148	0.	100.000			
4.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	6.1947E-01	173.35	26.65	0.01	73.34	226.63	0.	499.98			
						34.672	5.331	0.002	14.668	45.328	0.	100.000			
4.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	5.0150E-01	176.52	23.49	0.00	76.51	223.48	0.	500.00			
						35.303	4.697	0.000	15.302	44.697	0.	100.000			
6.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	5.9983E 09	249.50	25.25	74.75	0.00	1.01	0.	350.50			
						71.182	7.204	21.326	0.000	0.288	0.	100.000			
6.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	2.0888E 06	246.05	26.96	73.01	0.03	7.93	0.	353.98			
						69.510	7.617	20.626	0.008	2.240	0.	100.000			
6.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	8.3445E 03	234.40	32.56	66.95	0.49	31.69	0.	366.09			
						64.027	8.893	18.289	0.133	8.657	0.	100.000			
6.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	1.4607E 02	211.30	42.18	53.47	4.35	81.76	0.	393.05			
						53.758	10.731	13.605	1.107	20.800	0.	100.000			
6.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	7.9984E 00	182.34	48.32	33.66	21.02	156.34	0.	438.68			
						41.565	11.015	6.989	4.791	35.639	0.	100.000			
6.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	1.4907E 00	163.99	43.68	7.67	48.65	220.67	0.	484.66			
						33.836	9.012	1.583	10.038	45.531	0.	100.000			
6.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	7.6749E-01	164.47	36.39	0.86	62.75	233.81	0.	498.28			
						33.008	7.303	0.173	12.593	46.923	0.	100.000			
6.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	5.3882E-01	169.26	30.84	0.11	69.05	230.52	0.	499.79			
						33.867	6.171	0.021	13.816	46.125	0.	100.000			
6.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	4.1310E-01	173.36	26.66	0.02	73.33	226.60	0.	499.96			
						34.675	5.331	0.004	14.666	45.324	0.	100.000			
6.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	3.3435E-01	176.52	23.49	0.00	76.51	223.48	0.	499.99			
						35.304	4.697	0.001	15.302	44.696	0.	100.000			
12.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	5.9684E 09	249.64	25.18	74.82	0.00	0.71	0.	350.36			
						71.254	7.186	21.356	0.000	0.204	0.	100.000			
12.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	2.1124E 06	247.18	26.40	73.58	0.02	5.65	0.	352.83			
						70.057	7.482	20.855	0.005	1.601	0.	100.000			
12.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	8.6345E 03	238.65	30.51	69.16	0.33	23.03	0.	361.68			
						65.984	8.436	19.122	0.090	6.367	0.	100.000			
12.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	1.5273E 02	220.80	38.19	58.99	2.82	61.21	0.	382.02			
						57.800	9.996	15.442	0.739	16.023	0.	100.000			
12.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	7.7230E 00	195.91	44.93	40.83	14.24	122.42	0.	418.33			
						46.831	10.739	9.761	3.404	29.265	0.	100.000			
12.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	1.0660E 00	173.65	43.31	16.96	39.73	192.42	0.	466.07			
						37.258	9.293	3.640	8.523	41.286	0.	100.000			
12.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	4.1137E-01	166.56	36.50	3.06	60.43	227.31	0.	493.87			
						33.725	7.391	0.620	12.236	46.027	0.	100.000			
12.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	2.7192E-01	169.55	30.87	0.42	68.72	229.62	0.	499.17			
						33.967	6.184	0.084	13.766	46.000	0.	100.000			
12.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	2.0687E-01	173.41	26.66	0.07	73.27	226.45	0.	499.86			
						34.692	5.334	0.014	14.658	45.302	0.	100.000			
12.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	1.6723E-01	176.53	23.49	0.02	76.50	223.44	0.	499.97			
						35.308	4.698	0.003	15.300	44.691	0.	100.000			

TABLE F-24A

PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - CNH2N (100 MOLE C BASIS), STEAM/C RATIO, 4.0

P(ATM)	T(DEG F)	ELEMENTAL COMPOSITION				RT	EQUILIBRIUM PRODUCT COMPOSITIONS								TOTAL MOLES MOLE PC
		C(ATOMS) 100.00	H(ATOMS) 1600.00	O(ATOMS) 400.00	N2(MOLES) 0.		H2O MOLES MOLE PC	CO2 MOLES MOLE PC	CH4 MOLES MOLE PC	CO MOLES MOLE PC	H2 MOLES MOLE PC	N2 MOLES MOLE PC			
1.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	8.3934E 09	348.36 77.131	25.82 5.717	74.18 16.424	0.00 0.000	3.29 0.728	0. 0.	451.64 100.00			
1.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	2.7480E 06	337.68 73.029	31.12 6.731	68.80 14.889	0.07 0.916	24.71 5.345	0. 0.	462.39 100.00			
1.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	1.0355E 04	306.26 61.842	46.13 9.315	52.39 10.578	1.49 0.300	88.97 17.966	0. 0.	495.23 100.00			
1.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	2.2009E 02	259.67 46.958	63.83 11.543	23.50 4.251	12.66 2.290	193.32 34.958	0. 0.	552.99 100.00			
1.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	3.2039E 01	239.29 40.220	63.22 10.626	2.52 0.423	34.26 5.759	255.67 42.973	0. 0.	594.97 100.00			
1.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	1.5314E 01	246.22 41.054	53.92 8.990	0.13 0.022	45.95 7.662	253.52 42.272	0. 0.	599.73 100.00			
1.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	9.4593E 00	254.03 42.339	45.98 7.664	0.01 0.002	54.01 9.001	245.95 40.993	0. 0.	599.98 100.00			
1.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	6.5773E 00	260.23 43.372	39.77 6.628	0.00 0.000	60.23 10.038	239.76 39.961	0. 0.	600.00 100.00			
1.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	4.9426E 00	265.09 44.183	34.91 5.818	0.00 0.000	65.09 10.849	234.90 39.151	0. 0.	600.00 100.00			
1.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	3.9388E 00	268.87 44.811	31.13 5.189	0.00 0.000	68.87 11.478	231.13 38.522	0. 0.	600.00 100.00			
2.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	8.4220E 09	348.83 77.318	25.58 5.670	74.42 16.494	0.00 0.000	2.33 0.517	0. 0.	451.17 100.00			
2.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	2.8200E 06	341.10 74.321	29.43 6.412	70.52 15.366	0.05 0.011	17.86 3.890	0. 0.	458.95 100.00			
2.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	1.0802E 04	317.05 65.518	41.00 8.472	58.05 11.995	0.96 0.198	66.86 13.817	0. 0.	483.91 100.00			
2.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	2.0559E 02	276.46 51.952	57.46 10.797	33.92 6.374	8.62 1.620	155.69 29.257	0. 0.	532.16 100.00			
2.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	1.9297E 01	245.55 41.967	61.91 10.581	7.46 1.274	30.64 5.236	239.54 40.941	0. 0.	585.09 100.00			
2.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	7.7548E 00	246.65 41.180	53.87 8.994	0.52 0.087	45.61 7.615	252.31 42.125	0. 0.	598.96 100.00			
2.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	4.7343E 00	254.06 42.349	45.98 7.665	0.04 0.007	53.98 8.997	245.85 40.981	0. 0.	599.91 100.00			
2.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	3.2890E 00	260.24 43.374	39.77 6.628	0.01 0.001	60.23 10.038	239.75 39.959	0. 0.	599.99 100.00			
2.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	2.4713E 00	265.10 44.183	34.91 5.818	0.00 0.000	65.09 10.849	234.90 39.151	0. 0.	600.00 100.00			
2.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	1.9694E 00	268.87 44.811	31.13 5.189	0.00 0.000	68.87 11.478	231.13 38.522	0. 0.	600.00 100.00			
4.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	8.4082E 09	349.17 77.452	25.41 5.637	74.59 16.544	0.00 0.000	1.65 0.367	0. 0.	450.83 100.00			
4.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	2.8772E 06	343.60 75.280	28.18 6.175	71.78 15.727	0.03 0.007	12.83 2.811	0. 0.	456.43 100.00			
4.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	1.1265E 04	325.50 68.509	36.94 7.774	62.44 13.142	0.62 0.131	49.62 10.443	0. 0.	475.12 100.00			
4.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	2.0402E 02	292.05 56.861	51.14 9.956	43.19 8.409	5.67 1.105	121.57 23.670	0. 0.	513.62 100.00			
4.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	1.3966E 01	257.20 45.338	59.15 10.426	16.35 2.882	24.51 4.320	210.10 37.035	0. 0.	567.31 100.00			

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TABLE F-24B

PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED = CNH₂N (100 MOLE C BASIS), STEAM/C RATIO, 4.0

ELEMENTAL COMPOSITION				EQUILIBRIUM PRODUCT COMPOSITIONS												TOTAL				
C(ATOMS)	H(ATOMS)	O(ATOMS)	N2(MOLES)	CONDITIONS AND EQUILIBRIUM CONSTANTS			RT	H2O		CO2		CH4		CO		H2		N2		MOL
100.00	1000.00	400.00	0.	KR	KS	KC		MOL	PC	MOL	PC									
4.0000	1400.00	6.3697E-01	1.2081E-00	2.7306E-01	4.0621E-00			248.23		53.69		1.93		44.38		247.91		0.		596.15
								41.640		9.006		0.323		7.445		41.586		0.		100.000
4.0000	1600.00	8.2139E-02	8.2439E-01	4.0069E-02	2.3765E-00			254.19		45.98		0.17		53.85		245.47		0.		599.66
								42.390		7.667		0.028		8.981		40.934		0.		100.000
4.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	1.6453E-00			260.25		39.77		0.02		60.21		239.71		0.		599.96
								43.379		6.628		0.003		10.036		39.954		0.		100.000
4.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	1.2358E-00			265.10		34.91		0.00		65.09		234.89		0.		599.99
								44.184		5.818		0.001		10.849		39.150		0.		100.000
4.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	9.8473E-01			268.87		31.13		0.00		68.87		231.13		0.		600.00
								44.811		5.189		0.000		11.478		38.522		0.		100.000
6.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	8.5058E-09			349.32		25.34		74.66		0.00		1.35		0.		450.68
								77.511		5.622		16.567		0.000		0.300		0.		100.000
6.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	2.9042E-06			344.74		27.62		72.35		0.03		10.55		0.		455.29
								75.718		6.066		15.892		0.006		2.318		0.		100.000
6.0000	800.00	2.6585E-04	9.0223E-00	3.7690E-03	1.1526E-04			329.51		35.00		64.51		0.49		41.47		0.		470.98
								69.963		7.432		13.697		0.104		8.805		0.		100.000
6.0000	1000.00	4.9018E-02	3.7523E-00	6.4774E-01	2.0617E-02			300.16		47.72		47.87		4.41		104.10		0.		504.25
								59.525		9.463		9.494		0.875		20.644		0.		100.000
6.0000	1200.00	2.6875E-00	1.9714E-00	3.0042E-00	1.2507E-01			265.79		56.86		22.64		20.50		188.93		0.		554.71
								47.914		10.250		4.082		3.696		34.059		0.		100.000
6.0000	1400.00	6.3697E-01	1.2081E-00	2.7306E-01	2.8936E-00			250.45		53.43		3.88		42.69		241.78		0.		592.24
								42.290		9.021		0.655		7.208		40.825		0.		100.000
6.0000	1600.00	8.2139E-02	8.2439E-01	4.0069E-02	1.5945E-00			254.41		45.97		0.38		53.66		244.83		0.		599.24
								42.456		7.671		0.063		8.954		40.857		0.		100.000
6.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	1.0977E-00			260.28		39.77		0.05		60.19		239.63		0.		599.91
								43.387		6.629		0.008		10.032		39.944		0.		100.000
6.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	8.2394E-01			265.10		34.91		0.01		65.09		234.88		0.		599.98
								44.185		5.818		0.001		10.848		39.148		0.		100.000
6.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	6.5650E-01			268.87		31.13		0.00		68.86		231.13		0.		600.00
								44.812		5.189		0.000		11.477		38.522		0.		100.000
12.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	8.6021E-09			349.52		25.24		74.76		0.00		0.96		0.		450.48
								77.589		5.603		16.596		0.000		0.212		0.		100.000
12.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	2.9405E-06			346.24		26.87		73.11		0.02		7.54		0.		453.78
								76.302		5.922		16.112		0.004		1.661		0.		100.000
12.0000	800.00	2.6585E-04	9.0223E-00	3.7690E-03	1.1933E-04			335.01		32.33		67.34		0.32		30.30		0.		465.31
								71.997		6.949		14.473		0.070		6.512		0.		100.000
12.0000	1000.00	4.9018E-02	3.7523E-00	6.4774E-01	2.1257E-02			312.06		42.54		54.60		2.86		78.75		0.		490.80
								63.581		8.668		11.124		0.583		16.045		0.		100.000
12.0000	1200.00	2.6875E-00	1.9714E-00	3.0042E-00	1.1356E-01			281.27		52.22		33.49		14.29		151.75		0.		533.02
								52.769		9.797		6.283		2.681		28.470		0.		100.000
12.0000	1400.00	6.3697E-01	1.2081E-00	2.7306E-01	1.8334E-00			258.07		52.39		10.47		37.14		220.99		0.		579.06
								44.568		9.048		1.808		6.413		38.163		0.		100.000
12.0000	1600.00	8.2139E-02	8.2439E-01	4.0069E-02	8.2381E-01			255.52		45.91		1.43		52.66		241.62		0.		597.14
								42.790		7.688		0.239		8.819		40.463		0.		100.000
12.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	5.5111E-01			260.42		39.77		0.19		60.05		239.21		0.		599.63
								43.430		6.632		0.031		10.014		39.893		0.		100.000
12.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	4.1225E-01			265.13		34.91		0.03		65.06		234.81		0.		599.94
								44.192		5.818		0.005		10.845		39.139		0.		100.000
12.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	3.2830E-01			268.87		31.13		0.01		68.86		231.11		0.		599.99
								44.813		5.189		0.001		11.477		38.520		0.		100.000

TABLE F-25A

PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - CNH₂N (100 MOLE C BASIS), STEAM/C RATIO, 5.0

ELEMENTAL COMPOSITION				RT	EQUILIBRIUM PRODUCT COMPOSITIONS								TOTAL MOLES MOL PC
C(ATOMS)	H(ATOMS)	O(ATOMS)	N2(MOL%)		H2O MOLES MOL PC	CO2 MOLES MOL PC	CH4 MOLES MOL PC	CO MOLES MOL PC	H2 MOLES MOL PC	N2 MOLES MOL PC			
100.00	1200.00	500.00	0.										
CONDITIONS AND EQUILIBRIUM CONSTANTS				KR	KS	KC							
P(ATM)	T(DEG F)						RT						
1.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	1.0755E-10	447.94 81.141	26.03 4.715	13.97 13.399	0.00 0.000	4.11 0.745	0. 0.	552.36 100.000	
1.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	3.4958E-06	434.79 76.915	32.57 5.762	67.36 11.916	0.071 0.013	30.50 5.395	0. 0.	565.28 100.000	
1.0000	800.00	2.6585E-04	9.0223E-00	3.7690E-03	1.3414E-04	397.28 65.751	50.60 8.375	47.89 7.925	1.51 0.250	106.94 17.699	0. 0.	604.23 100.000	
1.0000	1000.00	4.9018E-02	3.7523E-00	6.4774E-01	3.2700E-02	346.03 51.958	70.97 10.657	17.01 2.553	124.02 1.805	219.95 33.027	0. 0.	665.99 100.000	
1.0000	1200.00	2.6875E-00	1.9714E-00	3.0042E-00	5.9723E-01	331.12 47.472	70.13 10.055	1.25 0.179	28.62 4.103	266.38 38.191	0. 0.	697.50 100.000	
1.0000	1400.00	6.3697E-01	1.2081E-00	2.7306E-01	2.8261E-01	339.01 48.440	61.05 8.723	0.07 0.009	38.88 5.556	260.86 37.272	0. 0.	699.87 100.000	
1.0000	1600.00	8.2139E-02	8.2439E-01	4.0069E-02	1.6857E-01	346.95 49.565	53.06 7.580	0.01 0.001	46.94 6.706	253.04 36.149	0. 0.	699.99 100.000	
1.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	1.1425E-01	353.42 50.489	46.58 6.654	0.00 0.000	53.42 7.632	246.58 35.225	0. 0.	700.00 100.000	
1.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	8.4300E-00	358.62 51.231	41.38 5.912	0.00 0.000	58.62 8.374	241.38 34.483	0. 0.	700.00 100.000	
1.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	6.6300E-00	362.73 51.819	37.27 5.324	0.00 0.000	62.73 8.961	237.27 33.896	0. 0.	700.00 100.000	
2.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	1.0746E-10	448.54 81.337	25.73 4.666	74.27 13.468	0.00 0.000	2.92 0.529	0. 0.	551.46 100.000	
2.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	3.5918E-06	438.97 78.236	30.49 5.434	69.46 12.380	0.05 0.009	22.11 3.941	0. 0.	561.08 100.000	
2.0000	800.00	2.6585E-04	9.0223E-00	3.7690E-03	1.3833E-04	409.98 69.370	44.52 7.534	54.50 9.222	0.98 0.165	81.02 13.709	0. 0.	591.00 100.000	
2.0000	1000.00	4.9018E-02	3.7523E-00	6.4774E-01	2.8452E-02	363.50 56.354	63.99 9.921	27.49 4.262	8.52 1.320	181.53 28.143	0. 0.	645.02 100.000	
2.0000	1200.00	2.6875E-00	1.9714E-00	3.0042E-00	3.3264E-01	335.17 48.463	69.02 9.980	4.19 0.606	26.79 3.873	256.44 37.078	0. 0.	691.61 100.000	
2.0000	1400.00	6.3697E-01	1.2081E-00	2.7306E-01	1.4221E-01	339.25 48.500	61.01 8.722	0.26 0.037	38.73 5.538	260.23 37.203	0. 0.	699.48 100.000	
2.0000	1600.00	8.2139E-02	8.2439E-01	4.0069E-02	8.4327E-00	346.97 49.570	53.05 7.580	0.02 0.003	46.92 6.704	252.99 36.143	0. 0.	699.96 100.000	
2.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	5.7130E-00	353.42 50.490	46.58 6.654	0.00 0.000	53.42 7.631	246.57 35.225	0. 0.	699.99 100.000	
2.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	4.2151E-00	358.62 51.231	41.38 5.912	0.00 0.000	58.62 8.374	241.38 34.483	0. 0.	700.00 100.000	
2.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	3.3150E-00	362.73 51.819	37.27 5.324	0.00 0.000	62.73 8.961	237.27 33.896	0. 0.	700.00 100.000	
4.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	1.0881E-10	448.97 81.477	25.52 4.631	74.48 13.517	0.00 0.000	2.07 0.376	0. 0.	551.04 100.000	
4.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	3.6703E-06	442.05 79.222	28.96 5.190	71.01 12.726	0.03 0.006	15.94 2.856	0. 0.	557.99 100.00	
4.0000	800.00	2.6585E-04	9.0223E-00	3.7690E-03	1.4348E-04	420.05 72.350	39.66 6.831	59.71 10.284	0.63 0.109	60.53 10.426	0. 0.	580.58 100.000	
4.0000	1000.00	4.9018E-02	3.7523E-00	6.4774E-01	2.7088E-02	380.82 60.941	56.73 9.078	37.55 6.009	5.72 0.915	144.08 23.056	0. 0.	624.99 100.000	
4.0000	1200.00	2.6875E-00	1.9714E-00	3.0042E-00	2.1636E-01	344.61 50.814	66.30 9.776	10.91 1.609	22.79 3.361	233.57 34.441	0. 0.	678.18 100.000	

CALIFORNIA RESEARCH
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RICHMOND, CALIFORNIA

RE 647688

TABLE F-25B

PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - CNH2N (100 MOLE C BASIS), STEAM/C RATIO, 5.0

ELEMENTAL COMPOSITION				EQUILIBRIUM PRODUCT COMPOSITIONS											
C(ATOMS)	H(ATOMS)	O(ATOMS)	N2(MOLES)	CONDITIONS AND EQUILIBRIUM CONSTANTS			RT	H2O	CO2	CH4	CO	H2	N2	TOTAL	
100.00	1200.00	500.00	0.	KR	KS	KC		MOL	MOL	MOL	MOL	MOL	MOL	MOLS	MOL
								PC	PC	PC	PC	PC	PC	PC	PC
4.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	7.2858E 00			349.16	60.84	0.99	38.17	257.86	0.	698.02	
								48.732	8.716	0.142	5.469	36.942	0.	100.000	
4.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	4.2249E 00			347.04	53.04	0.03	46.87	252.78	0.	699.83	
								49.590	7.580	0.012	6.697	36.121	0.	100.000	
4.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	2.8572E 00			353.43	46.58	0.01	53.41	246.55	0.	699.98	
								50.492	6.654	0.002	7.630	35.222	0.	100.000	
4.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	2.1076E 00			358.62	41.38	0.00	58.62	241.38	0.	700.00	
								51.232	5.912	0.000	8.374	34.482	0.	100.000	
4.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	1.6575E 00			362.73	37.27	0.00	62.73	237.27	0.	700.00	
								51.819	5.324	0.000	8.961	33.896	0.	100.000	
6.0000	400.00	7.9414E-12	2.0711E 02	4.00007E 09	1.0776E 10			449.15	25.42	74.58	0.01	1.69	0.	550.85	
								81.539	4.615	13.539	0.000	0.307	0.	100.000	
6.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	3.7096E 06			443.45	28.26	71.71	0.03	13.13	0.	556.58	
								79.674	5.078	12.884	0.005	2.359	0.	100.000	
6.0000	800.01	2.6585E-04	9.0223E 00	3.7690E 03	1.5170E 04			424.87	47.32	62.19	0.49	50.74	0.	575.63	
								73.809	6.483	10.803	0.086	8.819	0.	100.000	
6.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	2.6959E 02			390.11	52.71	42.82	4.47	124.26	0.	614.37	
								63.498	8.579	6.969	0.728	20.225	0.	100.000	
6.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	1.5584E 01			352.70	63.82	16.52	19.67	214.27	0.	666.97	
								52.881	9.568	2.476	2.949	32.126	0.	100.000	
6.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	5.0410E 00			341.52	60.57	2.10	37.33	254.28	0.	695.80	
								49.083	8.705	0.301	5.365	36.545	0.	100.000	
6.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	2.8260E 00			347.16	53.03	0.19	46.78	252.45	0.	699.61	
								49.622	7.580	0.028	6.686	36.084	0.	100.000	
6.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	1.9056E 00			353.45	46.58	0.02	53.40	246.50	0.	699.95	
								50.496	6.654	0.003	7.629	35.217	0.	100.000	
6.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	1.4052E 00			358.62	41.38	0.00	58.61	241.37	0.	699.99	
								51.233	5.912	0.001	8.374	34.482	0.	100.000	
6.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	1.1050E 00			362.73	37.27	0.00	62.73	237.27	0.	700.00	
								51.819	5.324	0.000	8.961	33.895	0.	100.000	
12.0000	400.00	7.9414E-12	2.0711E 02	4.00007E 09	1.0786E 10			449.40	25.30	74.70	0.00	1.20	0.	550.60	
								81.620	4.595	13.567	0.000	0.218	0.	100.000	
12.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	3.7625E 06			445.31	27.34	72.65	0.02	9.40	0.	554.71	
								80.279	4.928	13.096	0.003	1.694	0.	100.000	
12.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	1.5170E 04			431.52	34.08	65.60	0.33	37.28	0.	568.80	
								75.865	5.991	11.533	0.057	6.554	0.	100.000	
12.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	2.7345E 02			403.99	46.55	50.54	2.91	94.93	0.	598.92	
								67.454	7.772	8.439	0.487	15.849	0.	100.000	
12.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	1.5584E 01			368.80	58.49	27.30	14.21	176.61	0.	645.41	
								57.143	9.063	4.229	2.201	27.363	0.	100.000	
12.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	2.9383E 00			347.03	59.47	6.49	34.04	239.99	0.	687.01	
								50.512	8.656	0.945	4.955	34.932	0.	100.000	
12.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	1.4380E 00			347.80	52.95	0.75	46.30	250.69	0.	698.49	
								49.793	7.581	0.108	6.628	35.890	0.	100.000	
12.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	9.5487E-01			353.53	46.57	0.10	53.33	246.28	0.	699.81	
								50.518	6.655	0.014	7.621	35.192	0.	100.000	
12.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	7.0284E-01			358.64	41.38	0.02	58.60	241.33	0.	699.97	
								51.236	5.912	0.002	8.372	34.477	0.	100.000	
12.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	5.5256E-01			362.73	37.27	0.00	62.73	237.26	0.	699.99	
								51.820	5.324	0.001	8.961	33.895	0.	100.000	

TABLE F-26

PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - CNHN (100 MOLE % BASIS), STEAM/C RATIO, 1.0

ELEMENTAL COMPOSITION				EQUILIBRIUM PRODUCT COMPOSITIONS										
C(ATOMS)	H(ATOMS)	O(ATOMS)	N2(MOLS)	CONDITIONS AND EQUILIBRIUM CONSTANTS			RT	H2O MOLS MOL PC	CO2 MOLS MOL PC	CH4 MOLS MOL PC	CO MOLS MOL PC	H2 MOLS MOL PC	N2 MOLS MOL PC	TOTAL MOLS MOL PC
100.00	300.00	100.00	0.	KR	KS	KC								
1.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	7.5952E-03		0.73 0.295	0.30 0.120	1.03 0.415	98.67 39.797	147.21 59.373	0. 0.	247.94 100.000	
CONDITIONS LEAD TO CARBON FORMATION.														
1.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	2.5313E-03		0.32 0.127	0.10 0.040	0.42 0.167	99.48 39.926	148.85 59.739	0. 0.	249.17 100.000	
1.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	9.9807E-04		0.15 0.061	0.04 0.016	0.19 0.077	99.77 39.909	149.46 59.877	0. 0.	249.61 100.000	
2.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	7.5695E-03		1.42 0.579	0.58 0.237	2.01 0.817	97.41 39.599	144.56 58.768	0. 0.	245.98 100.000	
CONDITIONS LEAD TO CARBON FORMATION.														
2.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	2.5274E-03		0.63 0.252	0.20 0.080	0.83 0.332	98.97 39.853	147.72 59.482	0. 0.	248.35 100.000	
2.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	9.9731E-04		0.31 0.122	0.08 0.032	0.38 0.154	99.54 39.937	148.93 59.754	0. 0.	249.23 100.000	
4.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	7.5200E-03		2.71 1.117	1.12 0.463	3.83 1.580	95.05 39.221	139.63 57.618	0. 0.	242.34 100.000	
CONDITIONS LEAD TO CARBON FORMATION.														
4.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	2.5197E-03		1.23 0.497	0.39 0.159	1.62 0.656	97.99 39.710	145.54 58.979	0. 0.	246.76 100.000	
4.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	9.9580E-04		0.60 0.243	0.16 0.063	0.76 0.307	99.08 39.875	147.87 59.512	0. 0.	248.48 100.000	
6.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	7.4730E-03		3.87 1.620	1.62 0.677	5.49 2.297	92.89 38.863	135.15 56.543	0. 0.	239.92 100.000	
CONDITIONS LEAD TO CARBON FORMATION.														
6.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	2.5122E-03		1.80 0.734	0.58 0.236	2.38 0.970	97.04 39.570	143.44 58.490	0. 0.	245.24 100.000	
6.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	9.9430E-04		0.90 0.362	0.23 0.095	1.13 0.457	98.63 39.814	146.84 59.272	0. 0.	247.74 100.000	
12.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	7.3452E-03		6.80 2.947	2.92 1.266	9.71 4.213	87.37 37.892	123.78 53.682	0. 0.	230.57 100.000	
CONDITIONS LEAD TO CARBON FORMATION.														
12.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	2.4907E-03		3.39 1.407	1.11 0.459	4.50 1.865	94.40 39.168	137.62 57.101	0. 0.	241.01 100.000	
12.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	9.8991E-04		1.74 0.710	0.46 0.187	2.20 0.896	97.34 39.634	143.86 58.573	0. 0.	245.60 100.000	

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TABLE F-27A
PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA
STEAM REFORMER FEED - C₄H₁₀ (100 MOLE % BASIS), STEAM/C RATIO, 2.0

ELEMENTAL COMPOSITION				RT	EQUILIBRIUM PRODUCT COMPOSITIONS										TOTAL MOL %
C(ATM)	H(ATM)	C(ATM)	N2(MOL%)		H ₂ O MOL PC	CO ₂ MOL PC	CH ₄ MOL PC	CO MOL PC	H ₂ MOL PC	A ₂ MOL PC	MOL PC	MOL PC	MOL PC	MOL PC	
CONDITIONS LEAD TO CARBON FORMATION.															
1.0000	800.00	2.6585E-04	9.0223E 00	3.769CE 03	3.6396E 03	107.28 43.8E1	45.49 18.606	52.76 21.583	1.75 0.715	27.19 15.214	0. 0.	244.47 100.000			
1.0000	1000.00	4.901EE-02	3.7523E 00	6.4774E 01	6.6711E 01	85.7C 30.747	49.93 17.911	35.63 12.783	14.44 5.182	93.03 33.377	0. 0.	278.74 100.000			
1.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	5.712CE 00	68.92 20.895	41.16 12.480	1C.08 3.057	48.75 14.781	160.92 48.787	0. 0.	329.84 100.000			
1.0000	1400.00	6.3697E 01	1.2C81E 00	2.7306E-01	2.3983E 00	69.18 19.848	31.55 9.053	0.73 0.209	67.72 19.429	179.36 51.461	0. 0.	348.54 100.000			
1.0000	1600.00	8.2135E 02	8.2439E-01	4.0065E-C2	1.6445E 00	74.23 21.215	25.82 7.380	0.05 0.015	74.12 21.185	175.66 50.204	0. 0.	349.89 100.000			
1.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	1.2402E 00	78.29 22.370	21.71 6.204	0.01 0.002	78.28 22.366	171.70 49.058	0. 0.	349.99 100.000			
1.0000	2000.00	4.0C14E 04	4.7516E-01	2.2622E-03	9.8615E-01	81.35 23.244	18.65 5.328	0.00 0.000	81.35 23.244	168.64 48.184	0. 0.	350.00 100.000			
1.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	8.1772E-01	83.65 23.900	16.35 4.671	0.00 0.000	83.65 23.900	166.35 47.528	0. 0.	350.00 100.000			
2.0000	600.00	2.199CE-07	3.1479E 01	1.0438E 06	9.3934E 05	121.66 53.264	39.14 17.134	60.8C 26.617	0.07 0.030	6.75 2.955	0. 0.	228.41 100.000			
2.0000	800.00	2.6585E-04	9.0223E 00	3.769CE 03	3.7943E 03	111.98 46.814	43.43 18.156	55.4C 23.162	1.17 0.489	27.22 11.379	0. 0.	239.19 100.000			
2.0000	1000.00	4.901EE-02	3.7523E 00	6.4774E 01	6.8668E 01	94.32 35.552	48.02 18.1C1	42.35 15.961	9.63 3.630	70.99 26.756	0. 0.	265.31 100.000			
2.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	4.5278E 00	76.43 24.5C8	42.63 13.667	19.06 6.111	38.32 12.285	135.45 43.429	0. 0.	311.88 100.000			
2.0000	1400.00	6.3697E 01	1.2C81E 00	2.7306E-01	1.2901E 00	70.58 20.469	32.01 9.282	2.59 0.751	65.4C 18.967	174.24 50.531	0. 0.	344.82 100.000			
2.0000	1600.00	8.2135E 02	8.2439E-01	4.0065E-02	8.27C9E-01	74.35 21.269	25.86 7.398	0.21 0.061	73.93 21.148	175.22 50.124	0. 0.	349.57 100.000			
2.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	6.2051E-01	78.31 22.376	21.72 6.206	0.02 0.007	78.26 22.362	171.65 49.048	0. 0.	349.95 100.000			
2.0000	2000.00	4.0C14E 04	4.7516E-01	2.2622E-03	4.9312E-01	81.36 23.245	18.65 5.328	0.00 0.001	81.35 23.243	168.64 48.183	0. 0.	349.89 100.000			
2.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	4.0887E-01	83.65 23.901	16.35 4.671	0.00 0.000	83.65 23.900	166.35 47.528	0. 0.	350.00 100.000			
4.0000	600.00	2.199CE-07	3.1479E 01	1.0438E 06	9.4863E 05	122.62 53.917	38.67 17.001	61.29 26.948	0.05 0.021	6.81 2.113	0. 0.	227.43 100.000			
4.0000	800.00	2.6585E-04	9.0223E 00	3.769CE 03	3.9193E 03	115.53 49.1C4	41.84 17.784	57.37 24.384	0.79 0.337	19.74 8.390	0. 0.	235.27 100.000			
4.0000	1000.00	4.901EE-02	3.7523E 00	6.4774E 01	7.1309E 01	101.63 39.889	45.98 18.047	47.61 18.687	6.61 2.515	53.15 20.861	0. 0.	254.78 100.000			
4.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	4.0758E 00	85.08 29.049	43.49 14.848	28.56 9.753	27.95 9.543	1C7.8C 36.807	0. 0.	292.87 100.000			
4.0000	1400.00	6.3697E 01	1.2C81E 00	2.7306E-01	7.8700E-01	74.29 22.168	33.15 9.893	7.44 2.220	59.41 17.727	160.83 47.992	0. 0.	335.12 100.000			
4.0000	1600.00	8.2135E 02	8.2439E-01	4.0065E-02	4.2298E-01	74.81 21.476	26.01 7.465	0.82 0.236	73.17 21.005	173.54 49.818	0. 0.	348.36 100.000			
4.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	3.1167E-01	78.36 22.4C2	21.73 6.213	0.1C 0.028	78.17 22.346	171.44 49.011	0. 0.	349.81 100.000			
4.0000	2000.00	4.0C14E 04	4.7516E-01	2.2622E-03	2.4666E-01	81.37 23.249	18.65 5.329	0.02 0.004	81.33 23.240	168.6C 48.177	0. 0.	349.57 100.000			
4.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	2.0445E-01	83.65 23.902	16.35 4.671	0.00 0.001	83.65 23.900	166.34 47.526	0. 0.	349.99 100.000			

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TABLE F-27B
PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA
STEAM REFORMER FEED - CNHN (100 MOLE % BASIS), STEAM/C RATIO, 2.0

ELEMENTAL COMPOSITION				PRODUCT COMPOSITIONS												
C(ATM)	H(ATM)	C(ATM)	N2(MOL%)	CONDITIONS AND EQUILIBRIUM CONSTANTS			RT	H2O	CO2	CH4	CO	H2	N2	TOTAL MOLES		
100.00	500.00	200.00	0.	KR	KS	KC		MOL PC	MOL PC							
6.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	9.5285E 05			123.05	38.45	61.51	0.04	3.94	0.	226.99		
			CONDITIONS LEAD TO CARBON FORMATION.					54.211	16.941	27.097	0.017	1.734	0.	100.000		
6.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	3.9795E 03			117.16	41.10	58.27	0.62	16.30	0.	233.47		
								50.184	17.604	24.956	0.272	6.984	0.	100.000		
6.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	7.2900E 01			105.25	44.85	50.09	5.06	44.57	0.	249.81		
								42.130	17.952	20.052	2.026	17.840	0.	100.000		
6.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	3.9696E 00			90.06	43.60	33.65	22.75	92.63	0.	282.69		
								31.857	15.422	11.905	8.047	32.768	0.	100.000		
6.0000	1400.00	6.3697E 01	1.2681E 00	2.7306E-01	6.4001E-01			77.82	34.16	11.98	53.86	148.22	0.	326.04		
								23.868	10.478	3.675	16.519	45.460	0.	100.000		
6.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	2.9186E-01			75.52	26.22	1.74	72.03	171.00	0.	346.52		
								21.793	7.568	0.502	20.788	49.349	0.	100.000		
6.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	2.0827E-01			78.45	21.76	0.22	78.02	171.11	0.	349.57		
								22.443	6.225	0.062	22.320	48.950	0.	100.000		
6.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	1.6456E-01			81.38	18.65	0.04	81.31	168.55	0.	349.93		
								23.256	5.331	0.010	23.236	48.166	0.	100.000		
6.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	1.3632E-01			83.66	16.35	0.01	83.64	166.33	0.	349.99		
								23.903	4.672	0.002	23.899	47.524	0.	100.000		
12.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	9.5846E 05			123.62	38.18	61.79	0.03	2.79	0.	226.41		
			CONDITIONS LEAD TO CARBON FORMATION.					54.598	16.862	27.293	0.012	1.234	0.	100.000		
12.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	4.0629E 03			119.36	40.10	59.46	0.44	11.71	0.	231.07		
								51.657	17.354	25.734	0.189	5.067	0.	100.000		
12.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	7.5451E 01			110.36	43.12	53.48	3.40	32.67	0.	243.04		
								45.410	17.741	22.005	1.400	13.444	0.	100.000		
12.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	3.9202E 00			97.84	43.23	41.08	15.69	70.00	0.	267.84		
								36.530	16.141	15.336	5.858	26.135	0.	100.000		
12.0000	1400.00	6.3697E 01	1.2681E 00	2.7306E-01	5.1095E-01			85.42	36.05	21.47	42.49	121.65	0.	307.07		
								27.818	11.739	6.991	13.837	39.615	0.	100.000		
12.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	1.6835E-01			78.35	27.10	5.45	67.45	160.75	0.	339.10		
								23.106	7.992	1.608	19.890	47.464	0.	100.000		
12.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	1.0648E-01			78.93	21.90	0.83	77.27	169.41	0.	348.34		
								22.659	6.267	0.239	22.182	48.633	0.	100.000		
12.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	8.2584E-02			81.46	18.68	0.14	81.18	168.26	0.	349.72		
								23.294	5.340	0.040	23.214	48.112	0.	100.000		
12.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	6.8214E-02			83.66	16.35	0.03	83.62	166.26	0.	349.94		
								23.911	4.674	0.009	23.894	47.512	0.	100.000		

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TABLE F-28A

PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - CNHN (100 MOL C BASIS), STEAM/C RATIO, 3.0

P(ATM)	T(DEG F)	ELEMENTAL COMPOSITION				RT	EQUILIBRIUM PRODUCT COMPOSITIONS								TOTAL MOLS MOL PC
		C(ATOMS)	H(ATOMS)	O(ATOMS)	N2(MOLS)		H2O MOLS MOL PC	CO2 MOLS MOL PC	CH4 MOLS MOL PC	CO MOLS MOL PC	H2 MOLS MOL PC	N2 MOLS MOL PC			
1.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	4.8933E-09	224.03 68.726	37.99 11.653	62.01 19.024	0.00 0.000	1.95 0.597	0. 0.	325.97 100.000			
1.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	1.6657E-06	217.51 65.400	41.20 12.388	58.71 17.653	0.09 0.027	15.07 4.532	0. 0.	332.58 100.000			
1.0000	800.00	2.6585E-04	9.0223E-00	3.7690E-03	6.6616E-03	197.01 55.555	50.67 14.289	47.69 13.447	1.64 0.463	57.61 16.246	0. 0.	354.63 100.000			
1.0000	1000.00	4.9018E-02	3.7523E-00	6.4774E-01	1.3666E-02	164.32 41.178	61.16 15.326	25.48 --6.385	13.36 3.349	134.72 33.762	0. 0.	399.04 100.000			
1.0000	1200.00	2.6875E-00	1.9714E-00	3.0042E-00	1.6767E-01	146.48 33.110	57.32 12.955	3.80 0.858	38.89 8.790	195.93 44.287	0. 0.	442.41 100.000			
1.0000	1400.00	6.3697E-01	1.2081E-00	2.7306E-01	8.0924E-01	152.10 33.831	48.10 10.699	0.20 0.045	51.70 11.498	197.49 43.927	0. 0.	449.59 100.000			
1.0000	1600.00	8.2139E-02	8.2439E-01	4.0069E-02	5.2304E-02	159.25 35.391	40.76 9.059	0.02 0.003	59.22 13.161	190.72 42.385	0. 0.	449.97 100.000			
1.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	3.7584E-00	164.86 36.637	35.14 7.808	0.00 0.000	64.86 14.414	185.13 41.141	0. 0.	456.00 100.000			
1.0000	2000.00	4.3014E-04	4.7516E-01	2.2622E-03	2.8915E-00	169.22 37.604	30.78 6.841	0.00 0.000	69.22 15.381	180.78 40.174	0. 0.	450.00 100.000			
1.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	2.3439E-00	172.57 38.349	27.43 6.096	0.00 0.000	72.57 16.126	177.43 39.429	0. 0.	450.00 100.000			
2.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	4.8663E-09	224.31 68.873	37.84 11.620	62.16 19.084	0.00 0.000	1.38 0.423	0. 0.	325.69 100.000			
2.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	1.6883E-06	219.63 66.470	40.15 12.151	59.79 18.093	0.06 0.019	10.79 3.267	0. 0.	330.43 100.000			
2.0000	800.00	2.6585E-04	9.0223E-00	3.7690E-03	6.8717E-03	204.27 58.896	47.32 13.644	51.59 14.874	1.09 0.315	42.56 12.271	0. 0.	346.83 100.000			
2.0000	1000.00	4.9018E-02	3.7523E-00	6.4774E-01	1.3205E-02	176.74 46.224	57.09 14.930	33.82 8.846	9.09 2.378	105.61 27.622	0. 0.	382.35 100.000			
2.0000	1200.00	2.6875E-00	1.9714E-00	3.0042E-00	1.0952E-01	153.00 35.547	56.80 13.196	9.80 2.276	33.41 7.762	177.41 41.219	0. 0.	430.41 100.000			
2.0000	1400.00	6.3697E-01	1.2081E-00	2.7306E-01	4.1345E-03	152.66 34.042	48.13 10.732	0.78 0.175	51.09 11.393	195.78 43.658	0. 0.	448.43 100.000			
2.0000	1600.00	8.2139E-02	8.2439E-01	4.0069E-02	2.6195E-00	159.29 35.408	40.77 9.062	0.06 0.014	59.17 13.152	190.58 42.364	0. 0.	449.88 100.000			
2.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	1.8796E-03	164.87 36.639	35.14 7.809	0.01 0.002	64.85 14.413	185.12 41.138	0. 0.	449.99 100.000			
2.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	1.4458E-00	169.22 37.604	30.78 6.841	0.00 0.000	69.21 15.381	180.78 40.174	0. 0.	450.00 100.000			
2.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	1.1720E-00	172.57 38.349	27.43 6.096	0.00 0.000	72.57 16.126	177.43 39.429	0. 0.	450.00 100.000			
4.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	4.8783E-09	224.51 68.977	37.74 11.596	62.26 19.127	0.00 0.000	0.98 0.300	0. 0.	325.49 100.000			
4.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	1.7051E-06	221.17 67.251	39.39 11.978	60.56 18.416	0.04 0.013	7.70 2.342	0. 0.	328.87 100.000			
4.0000	800.00	2.6585E-04	9.0223E-00	3.7690E-03	7.0610E-03	209.82 61.545	44.72 13.119	54.54 15.998	0.73 0.216	31.10 9.122	0. 0.	340.92 100.000			
4.0000	1000.00	4.9018E-02	3.7523E-00	6.4774E-01	1.3237E-02	187.73 50.963	53.10 14.415	40.82 11.083	6.08 1.650	80.63 21.889	0. 0.	368.35 100.000			
4.0000	1200.00	2.6875E-00	1.9714E-00	3.0042E-00	8.5665E-00	163.07 39.503	55.53 13.453	18.60 4.506	25.87 6.266	149.73 36.272	0. 0.	412.80 100.000			

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TABLE F-288
PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - CNHN (100 MOLE % BASIS), STEAM/C RATIO, 3.0

P(MPa)	T(DEG F)	ELEMENTAL COMPOSITION			RT	EQUILIBRIUM PRODUCT COMPOSITIONS								TOTAL MOLES MOLE PC
		C(ATOMS)	H(ATOMS)	O(ATOMS)		H2O MOLES MOLE PC	CO2 MOLES MOLE PC	CH4 MOLES MOLE PC	CO MOLES MOLE PC	H2 MOLES MOLE PC	N2 MOLES MOLE PC			
4.0000	1400.0	6.3697E 01	1.2081E 00	2.7306E-01	2.2283E 02	154.56 34.773	48.21 10.846	2.76 0.622	49.03 11.031	189.92 42.729	0. 0.	444.47		100.000
4.0000	1600.0	8.2139E 02	8.2439E-01	4.0069E-02	1.3182E 01	159.46 35.474	40.79 9.074	0.24 0.054	58.97 13.118	190.75 42.280	0. 0.	449.51		100.000
4.0000	1800.0	6.7984E 03	6.0833E-01	8.3445E-03	9.4047E-01	164.89 36.647	35.14 7.810	0.03 0.006	64.83 14.409	185.05 41.128	0. 0.	449.94		100.000
4.0000	2000.0	4.0014E 04	4.7516E-01	2.2622E-03	7.2299E-01	169.22 37.605	30.78 6.841	0.00 0.001	69.21 15.380	180.77 40.172	0. 0.	449.99		100.000
4.0000	2200.0	1.8036E 05	3.8864E-01	7.5373E-04	5.8600E-01	172.57 38.349	27.43 6.096	0.00 0.000	72.57 16.126	177.43 39.429	0. 0.	450.00		100.000
6.0000	400.0	7.9414E-12	2.0711E 02	4.0007E 09	4.8692E 09	224.60 69.024	37.70 11.585	62.30 19.146	0.00 0.000	0.80 0.245	0. 0.	325.40		100.00
6.0000	600.0	2.1990E-07	3.1479E 01	1.0438E 06	1.7129E 06	221.86 67.604	39.05 11.900	60.91 18.561	0.04 0.011	6.31 1.924	0. 0.	328.17		100.000
6.0000	800.0	2.6585E-04	9.0223E 00	3.7690E-03	7.1581E-03	212.40 62.807	43.51 12.665	55.91 16.532	0.59 0.173	25.78 7.623	0. 0.	338.18		100.000
6.0000	1000.0	4.9018E-02	3.7523E 00	6.4774E 01	1.3363E 02	193.29 53.467	50.96 14.097	44.25 12.240	4.79 1.326	68.22 18.871	0. 0.	361.11		100.000
6.0000	1200.0	2.6875E 00	1.9714E 00	3.0042E 00	7.9088E 00	169.73 42.250	54.40 13.542	24.14 6.008	21.46 5.342	132.00 32.857	0. 0.	401.73		100.000
6.0000	1400.0	6.3697E 01	1.2081E 00	2.7306E-01	1.6386E 00	156.98 35.721	48.28 10.986	5.26 1.198	46.46 10.571	182.49 41.525	0. 0.	439.47		100.000
6.0000	1600.0	8.2139E 02	8.2439E-01	4.0069E-02	8.8796E-01	159.73 35.580	40.82 9.092	0.54 0.120	58.64 13.063	189.19 42.144	0. 0.	448.92		100.000
6.0000	1800.0	6.7984E 03	6.0833E-01	8.3445E-03	6.2775E-01	164.92 36.659	35.15 7.812	0.07 0.014	64.79 14.402	184.95 41.112	0. 0.	449.87		100.000
6.0000	2000.0	4.0014E 04	4.7516E-01	2.2622E-03	4.8209E-01	169.23 37.607	30.79 6.842	0.01 0.002	69.20 15.379	180.75 40.169	0. 0.	449.98		100.000
6.0000	2200.0	1.8036E 05	3.8864E-01	7.5373E-04	3.9068E-01	172.57 38.350	27.43 6.096	0.00 0.001	72.57 16.126	177.42 39.428	0. 0.	450.00		100.000
12.0000	400.0	7.9414E-12	2.0711E 02	4.0007E 09	4.8692E 09	224.72 69.084	37.64 11.572	62.36 19.171	0.00 0.000	0.56 0.173	0. 0.	325.28		100.000
12.0000	600.0	2.1990E-07	3.1479E 01	1.0438E 06	1.7235E 06	222.77 68.071	38.60 11.796	61.37 18.753	0.02 0.008	4.49 1.372	0. 0.	327.26		100.000
12.0000	800.0	2.6585E-04	9.0223E 00	3.7690E 03	7.2992E 03	215.90 64.542	41.85 12.512	57.75 17.264	0.40 0.120	18.61 5.563	0. 0.	334.50		100.000
12.0000	1000.0	4.9018E-02	3.7523E 00	6.4774E 01	1.3654E 02	201.28 57.193	47.76 13.571	49.04 13.934	3.20 0.910	50.65 14.392	0. 0.	351.93		100.000
12.0000	1200.0	2.6875E 00	1.9714E 00	3.0042E 00	7.3788E 00	180.99 47.128	52.00 13.540	32.98 8.589	15.02 3.910	103.05 26.833	0. 0.	384.03		100.000
12.0000	1400.0	6.3697E 01	1.2081E 00	2.7306E-01	1.1133E 01	164.14 38.614	48.32 11.368	12.46 2.931	39.22 9.226	160.94 37.861	0. 0.	425.08		100.000
12.0000	1600.0	8.2139E 02	8.2439E-01	4.0069E-02	4.6730E-01	161.03 36.101	40.95 9.181	1.98 0.443	57.07 12.795	185.02 41.479	0. 0.	446.14		100.000
12.0000	1800.0	6.7984E 03	6.0833E-01	8.3445E-03	3.1592E-01	165.09 36.728	35.17 7.824	0.26 0.057	64.57 14.366	184.40 41.024	0. 0.	449.49		100.000
12.0000	2000.0	4.0014E 04	4.7516E-01	2.2622E-03	2.4130E-01	169.25 37.619	30.79 6.843	0.04 0.010	69.17 15.373	180.66 40.155	0. 0.	449.91		100.000
12.0000	2200.0	1.8036E 05	3.8864E-01	7.5373E-04	1.9539E-01	172.58 38.352	27.43 6.096	0.01 0.002	72.56 16.125	177.40 39.425	0. 0.	449.98		100.000

TABLE F-29A

PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - CNH₄ (100 MOLE BASIS), STEAM/C RATIO, 4.

P(MPa)	T(DEG F)	ELEMENTAL COMPOSITION			RT	EQUILIBRIUM PRODUCT COMPOSITIONS								TOTAL MOLES MOLE PC
		C(ATOMS)	H(ATOMS)	N(MOLES)		H ₂ O MOLES MOLE PC	CO ₂ MOLES MOLE PC	CH ₄ MOLES MOLE PC	CO MOLES MOLE PC	H ₂ MOLES MOLE PC	N ₂ MOLES MOLE PC			
1.0000	400.0	7.9414E-12	2.0711E-02	4.0007E-09	7.0237E-09	323.67 75.918	38.17 8.952	61.83 14.533	0.51 0.000	2.67 2.626	0. 0.	426.4		100.00
1.0000	600.0	2.1990E-07	3.1479E-01	1.0438E-06	2.3996E-06	314.81 72.325	42.55 9.775	57.36 13.173	0.09 0.020	20.46 4.730	0. 0.	435.27		100.00
1.0000	800.0	2.6585E-04	9.0223E-03	3.7690E-03	9.8005E-03	287.82 62.057	55.28 11.919	43.16 9.293	1.62 0.349	75.98 16.362	0. 0.	463.80		100.00
1.0000	1000.0	4.9018E-02	3.7523E-00	6.4774E-01	2.3111E-02	248.08 48.228	69.73 13.557	17.81 3.462	12.46 2.422	166.33 32.331	0. 0.	514.38		100.00
1.0000	1200.0	2.6875E-00	1.9714E-03	3.0042E-03	3.8264E-01	234.20 42.829	67.38 12.323	1.58 0.290	31.03 5.675	212.63 38.884	0. 0.	546.83		100.00
1.0000	1400.0	6.3697E-01	1.2081E-00	2.7306E-01	1.8561E-01	241.74 43.965	58.35 10.611	0.08 0.015	41.57 7.561	208.10 37.848	0. 0.	549.84		100.00
1.0000	1600.0	8.2139E-02	8.2439E-01	4.0069E-02	1.1616E-01	249.39 45.345	50.61 9.203	0.01 0.001	49.38 8.979	200.59 36.472	0. 0.	549.99		100.00
1.0000	1800.0	6.7984E-03	6.0833E-01	8.3445E-03	7.9145E-04	255.57 46.467	44.43 8.079	0.00 0.000	55.57 10.103	194.43 35.351	0. 0.	550.00		100.00
1.0000	2000.0	4.0014E-04	4.7516E-01	2.2622E-03	5.9384E-04	260.49 47.362	39.51 7.183	0.00 0.000	60.49 10.998	189.51 34.456	0. 0.	550.00		100.00
1.0000	2200.0	1.8036E-05	3.8864E-01	7.5373E-04	4.7292E-05	264.37 48.067	35.63 6.478	0.00 0.000	64.37 11.704	185.63 33.751	0. 0.	550.00		100.00
2.0000	400.0	7.9414E-12	2.0711E-02	4.0007E-09	7.0885E-09	324.05 76.079	37.97 8.915	62.03 14.562	0.00 0.000	1.89 0.444	0. 0.	425.95		100.00
2.0000	600.0	2.1990E-07	3.1479E-01	1.0438E-06	2.4326E-06	317.68 73.473	41.13 9.512	58.81 13.601	0.06 0.014	14.79 3.400	0. 0.	432.38		100.00
2.0000	800.0	2.6585E-04	9.0223E-03	3.7690E-03	9.9910E-03	297.20 65.482	50.86 11.206	48.06 10.590	1.07 0.237	56.67 12.485	0. 0.	453.87		100.00
2.0000	1000.0	4.9018E-02	3.7523E-00	6.4774E-01	2.0734E-02	262.32 52.836	64.45 12.982	26.77 5.391	8.78 1.769	134.15 27.021	0. 0.	496.47		100.00
2.0000	1200.0	2.6875E-00	1.9714E-00	3.0042E-03	2.2099E-01	238.49 44.164	66.50 12.315	4.99 0.925	28.50 5.279	201.52 37.318	0. 0.	540.01		100.00
2.0000	1400.0	6.3697E-01	1.2081E-00	2.7306E-01	9.3627E-00	242.00 44.050	58.32 10.616	0.32 0.058	41.36 7.529	207.37 37.747	0. 0.	549.37		100.00
2.0000	1600.0	8.2139E-02	8.2439E-01	4.0069E-02	5.7116E-06	249.41 45.352	50.61 9.203	0.03 0.005	49.36 8.976	200.54 36.464	0. 0.	549.95		100.00
2.0000	1800.0	6.7984E-03	6.0833E-01	8.3445E-03	3.9576E-05	255.57 46.468	44.43 8.079	0.03 0.001	55.56 10.163	194.42 35.350	0. 0.	549.99		100.00
2.0000	2000.0	4.0014E-04	4.7516E-01	2.2622E-03	2.9693E-06	260.49 47.362	39.51 7.183	0.00 0.000	60.49 10.998	189.51 34.456	0. 0.	550.00		100.00
2.0000	2200.0	1.8036E-05	3.8864E-01	7.5373E-04	2.3646E-06	264.37 48.067	35.63 6.478	0.00 0.000	64.37 11.704	185.63 33.751	0. 0.	550.00		100.00
4.0000	400.0	7.9414E-12	2.0711E-02	4.0007E-09	6.9867E-09	324.33 76.193	37.83 8.888	62.16 14.604	0.00 0.000	1.34 0.315	0. 0.	425.67		100.00
4.0000	600.0	2.1990E-07	3.1479E-01	1.0438E-06	2.4581E-06	319.76 74.315	40.10 9.319	59.86 13.912	0.04 0.010	10.52 2.444	0. 0.	430.28		100.00
4.0000	800.0	2.6585E-04	9.0223E-03	3.7690E-03	1.0206E-04	304.50 68.239	47.39 10.629	51.89 11.629	0.72 0.161	41.72 9.350	0. 0.	446.22		100.00
4.0000	1000.0	4.9018E-02	3.7523E-00	6.4774E-01	1.9929E-02	275.77 57.427	59.13 12.314	34.90 7.267	5.97 1.243	104.44 21.749	0. 0.	480.20		100.00
4.0000	1200.0	2.6875E-00	1.9714E-00	3.0042E-03	1.5127E-01	247.82 46.985	64.50 12.253	11.81 2.244	23.69 4.500	179.06 34.917	0. 0.	526.37		100.00

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TABLE F-298

PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - C₄H₁₀ (100 MOLE % BASIS), STEAM/C RATIO, 4.0

ELEMENTAL COMPOSITION				EQUILIBRIUM PRODUCT COMPOSITIONS										TOTAL MOLES MOLE PC
C(ATOMS)	H(ATOMS)	O(ATOMS)	N2(MOLE)		H2O MOLES MOLE PC	CO2 MOLES MOLE PC	CH4 MOLES MOLE PC	CO MOLES MOLE PC	H2 MOLES MOLE PC	N2 MOLES MOLE PC				
167.00	931.00	400.00	0.											
CONDITIONS AND EQUILIBRIUM CONSTANTS				RT										
P(ATM)	T(DEG F)	KR	KS	KC										
4.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	4.8396E 00	242.98 44.371	58.22 10.632	1.20 0.219	40.58 7.411	294.62 37.367	0. 0.	547.60 100.00		
4.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	2.8636E 01	249.49 45.379	50.61 9.205	0.10 0.019	49.29 8.965	200.33 36.432	0. 0.	549.80 100.00		
4.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	1.9794E 00	255.58 46.471	44.43 8.079	0.01 0.002	55.56 10.161	194.4n 35.346	0. 0.	549.98 100.00		
4.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	1.4847E 00	260.49 47.363	39.51 7.183	0.00 0.000	60.49 10.998	189.5n 34.455	0. 0.	550.00 100.00		
4.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	1.1823E 00	264.37 48.068	35.63 6.478	0.00 0.000	64.37 11.764	185.63 33.751	0. 0.	550.00 100.00		
6.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	7.0150E 09	324.45 76.244	37.77 8.876	62.23 14.623	0.00 0.000	1.39 0.257	0. 0.	425.55 100.00		
6.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	2.4697E 06	320.70 74.698	39.63 9.231	60.33 14.053	0.03 0.008	8.63 2.010	0. 0.	429.33 100.00		
6.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	1.0328E 04	307.93 69.566	45.75 10.336	53.68 12.127	0.57 0.129	34.72 7.843	0. 0.	442.64 100.00		
6.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	1.9815E 02	282.79 59.921	56.24 11.917	39.03 8.271	4.73 1.001	89.15 18.889	0. 0.	471.94 100.00		
6.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	1.3148E 01	254.23 49.266	62.76 12.161	16.98 3.291	20.26 3.926	161.81 31.356	0. 0.	516.03 100.00		
6.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	3.3889E 00	244.41 44.843	58.07 10.654	2.48 0.455	39.45 7.239	200.63 36.810	0. 0.	545.04 100.00		
6.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	1.9176E 01	249.62 45.423	50.61 9.209	0.23 0.042	49.16 8.946	199.92 36.380	0. 0.	549.54 100.00		
6.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	1.3203E 00	255.59 46.477	44.43 8.080	0.03 0.005	55.54 10.099	194.35 35.340	0. 0.	549.94 100.00		
6.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	9.8989E-01	260.50 47.364	39.51 7.184	0.00 0.001	60.49 10.998	189.49 34.454	0. 0.	549.99 100.00		
6.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	7.8823E-01	264.37 48.068	35.63 6.478	0.00 0.000	64.37 11.764	185.63 33.750	0. 0.	550.00 100.00		
12.0000	400.00	7.9414E-12	2.0711E 02	4.0007E 09	6.9431E 09	324.61 76.310	37.69 8.861	62.31 14.647	0.00 0.000	0.77 0.182	0. 0.	425.39 100.00		
12.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	2.4860E 06	321.94 75.205	39.02 9.115	60.96 14.240	0.02 0.006	6.15 1.436	0. 0.	428.08 100.00		
12.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	1.0517E 04	312.60 71.405	43.50 9.937	56.11 12.816	0.39 0.089	25.19 5.753	0. 0.	437.79 100.00		
12.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	1.9923E 02	293.09 63.705	51.88 11.276	44.96 9.773	3.16 0.687	66.98 14.559	0. 0.	460.07 100.00		
12.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	1.1449E 01	267.14 53.698	59.11 11.682	26.26 5.278	14.63 2.941	130.34 26.201	0. 0.	497.49 100.00		
12.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	2.0470E 01	249.74 46.623	57.44 10.723	7.17 1.339	35.39 6.607	185.91 34.7-8	0. 0.	535.65 100.00		
12.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	9.8119E-01	250.29 45.653	50.59 9.227	0.88 0.160	48.53 8.853	197.96 36.1u7	0. 0.	548.25 100.00		
12.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	6.6202E-01	255.68 46.505	44.44 8.682	0.11 0.020	55.45 10.087	194.19 35.3u5	0. 0.	549.78 100.00		
12.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	4.9517E-01	260.51 47.368	39.51 7.184	0.02 0.003	63.47 10.996	189.45 34.448	0. 0.	549.96 100.00		
12.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	3.9416E-01	264.37 48.069	35.63 6.478	0.00 0.001	64.37 11.703	185.62 33.749	0. 0.	549.99 100.00		

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TABLE F-30A

PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

STEAM REFORMER FEED - CNHN (100 MOLE % BASIS), STEAM/C RATIO 5.0

ELEMENTAL COMPOSITION				EQUILIBRIUM PRODUCT COMPOSITIONS											
C(ATOMS)	H(ATOMS)	O(ATOMS)	N2(MOL%)	CONDITIONS AND EQUILIBRIUM CONSTANTS			RT	H2O MOLS MOL PC	CO2 MOLS MOL PC	CH4 MOLS MOL PC	CO MOLS MOL PC	H2 MOLS MOL PC	N2 MOLS MOL PC	TOTAL MOLS MOL PC	
100.00	1100.00	500.00	0.	P(ATM)	T(DEG F)	KR	KS	KC							
1.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	9.1718E-09	423.31	38.35	61.65	0.00	3.39	0.	526.69			
						80.371	7.280	11.706	0.000	0.643	0.	100.00			
1.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	3.1309E-06	412.20	43.86	56.06	0.09	25.68	0.	537.88			
						76.634	8.153	10.422	0.016	4.774	0.	100.00			
1.0000	800.00	2.6585E-04	9.0223E-00	3.7690E-03	1.3109E-04	379.44	59.48	38.91	1.61	92.74	0.	572.17			
						66.315	10.395	6.801	0.282	16.208	0.	100.00			
1.0000	1000.00	4.9018E-02	3.7523E-00	6.4774E-01	3.6155E-02	335.86	76.32	12.19	11.49	189.76	0.	625.63			
						53.685	12.199	1.948	1.837	30.332	0.	100.00			
1.0000	1200.00	2.6875E-00	1.9714E-00	3.0042E-00	7.4254E-01	326.89	73.85	0.75	25.40	221.61	0.	648.50			
						50.407	11.388	0.115	3.916	34.173	0.	100.00			
1.0000	1400.00	6.3697E-01	1.2081E-00	2.7306E-01	3.5204E-01	334.79	65.25	0.04	34.71	215.14	0.	649.92			
						51.511	10.040	0.006	5.340	33.102	0.	100.00			
1.0000	1600.00	8.2139E-02	8.2439E-01	4.0069E-02	2.0853E-01	342.39	57.62	0.00	42.38	207.61	0.	649.99			
						52.675	8.864	0.000	6.520	31.940	0.	100.00			
1.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	1.4066E-01	348.69	51.31	0.00	48.69	201.31	0.	650.00			
						53.645	7.893	0.000	7.491	30.970	0.	100.00			
1.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	1.0347E-01	353.85	46.15	0.00	53.85	196.15	0.	650.00			
						54.438	7.101	0.000	8.284	30.177	0.	100.00			
1.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	8.1222E-00	357.99	42.01	0.00	57.99	192.01	0.	650.00			
						55.075	6.464	0.000	8.921	29.541	0.	100.00			
2.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	9.1753E-09	423.80	38.10	61.90	0.00	2.40	0.	526.26			
						80.540	7.240	11.763	0.000	0.456	0.	100.00			
2.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	3.1733E-06	415.77	42.08	57.86	0.06	18.51	0.	534.29			
						77.819	7.877	10.829	0.011	3.465	0.	100.00			
2.0000	800.00	2.6585E-04	9.0223E-00	3.7690E-03	1.3185E-04	390.63	54.15	44.78	1.07	69.82	0.	560.45			
						69.699	9.662	7.989	0.191	12.458	0.	100.00			
2.0000	1000.00	4.9018E-02	3.7523E-00	6.4774E-01	2.9915E-02	350.36	70.59	20.94	8.47	157.75	0.	608.11			
						57.614	11.607	3.444	1.393	25.942	0.	100.00			
2.0000	1200.00	2.6875E-00	1.9714E-00	3.0042E-00	4.0138E-01	329.49	73.14	2.63	24.24	215.26	0.	644.75			
						51.104	11.343	0.407	3.759	33.386	0.	100.00			
2.0000	1400.00	6.3697E-01	1.2081E-00	2.7306E-01	1.7678E-01	334.93	65.23	0.15	34.62	214.77	0.	649.70			
						51.551	10.040	0.023	5.329	33.057	0.	100.00			
2.0000	1600.00	8.2139E-02	8.2439E-01	4.0069E-02	1.0430E-01	342.40	57.62	0.01	42.37	207.58	0.	649.97			
						52.678	8.864	0.002	6.519	31.936	0.	100.00			
2.0000	1800.00	6.7984E-03	6.0833E-01	8.3445E-03	7.0334E-00	348.69	51.31	0.00	48.69	201.30	0.	650.00			
						53.646	7.893	0.000	7.491	30.970	0.	100.00			
2.0000	2000.00	4.0014E-04	4.7516E-01	2.2622E-03	5.1735E-00	353.85	46.15	0.00	53.85	196.15	0.	650.00			
						54.438	7.101	0.000	8.284	30.177	0.	100.00			
2.0000	2200.00	1.8036E-05	3.8864E-01	7.5373E-04	4.0611E-00	357.99	42.01	0.00	57.99	192.01	0.	650.00			
						55.075	6.464	0.000	8.921	29.541	0.	100.00			
4.0000	400.00	7.9414E-12	2.0711E-02	4.0007E-09	9.1979E-09	424.15	37.92	62.07	0.00	1.70	0.	525.85			
						80.660	7.212	11.805	0.000	0.323	0.	100.00			
4.0000	600.00	2.1990E-07	3.1479E-01	1.0438E-06	3.2065E-06	418.38	40.79	59.17	0.04	13.27	0.	531.66			
						78.694	7.672	11.130	0.008	2.497	0.	100.00			
4.0000	800.00	2.6585E-04	9.0223E-00	3.7690E-03	1.3375E-04	399.47	49.91	49.37	0.72	51.79	0.	551.25			
						72.465	9.054	8.957	0.130	9.394	0.	100.00			
4.0000	1000.00	4.9018E-02	3.7523E-00	6.4774E-01	2.7419E-02	365.28	64.41	29.70	5.89	125.32	0.	590.61			
						61.849	10.906	5.028	0.997	21.219	0.	100.00			
4.0000	1200.00	2.6875E-00	1.9714E-00	3.0042E-00	2.4728E-01	336.18	71.22	7.40	21.39	199.02	0.	635.20			
						52.925	11.211	1.165	3.367	31.332	0.	100.00			

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TABLE F-30B
PRODUCT COMPOSITIONS FROM HYDROCARBON STEAM REFORMING AND SHIFT EQUILIBRIA

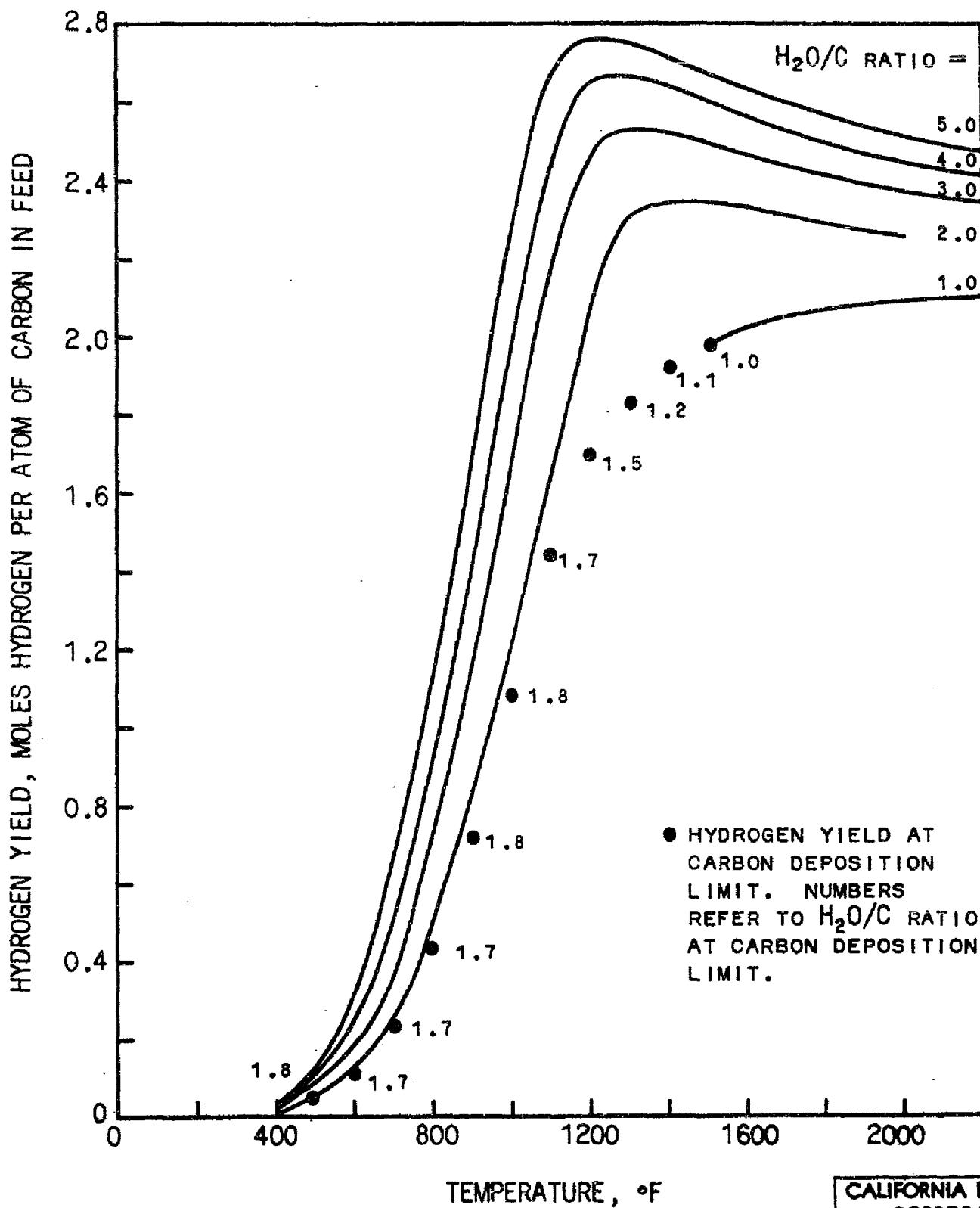
STEAM REFORMER FEED - C₆H₆NH₂ (100 MOLE % BASIS), STEAM/C RATIO 5.0

ELEMENTAL COMPOSITION				EQUILIBRIUM PRODUCT COMPOSITIONS												
C(ATOMS)	H(ATOMS)	O(ATOMS)	N2(MOLS)	P(ATM) T(DEG F)		KR	KS	KC	RT	H2O	CO2	CH4	CO	H2	N2	TOTAL
100.00	1100.00	500.00	0.							MOL	MOL	MOL	MOL	MOL	MOL	MOL
										MOL PC	MOL PC	MOL PC	MOL PC	MOL PC	MOL PC	MOL PC
4.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	8.9881E 01	335.47	65.13	0.59	34.28	213.35	0.	648.82				
						51.704	10.038	0.091	5.284	32.883	0.	100.000				
4.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	5.2221E 00	342.44	57.61	0.05	42.34	207.46	0.	649.90				
						52.691	8.865	0.008	6.514	31.922	0.	100.000				
4.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	3.5173E 00	348.70	51.31	0.01	48.69	201.29	0.	649.99				
						53.664	7.894	0.001	7.490	30.968	0.	100.000				
4.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	2.5868E 00	353.85	46.15	0.00	53.85	196.15	0.	650.00				
						54.438	7.101	0.000	8.284	30.177	0.	100.000				
4.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	2.0306E 00	357.99	42.01	0.00	57.99	192.01	0.	650.00				
						55.075	6.464	0.000	8.921	29.541	0.	100.000				
6.0000	400.00	7.9414E-12	2.0711E 02	4.00007E 09	9.1281E 09	424.31	37.85	62.15	0.00	1.39	0.	525.70				
						80.713	7.199	11.823	0.000	0.264	0.	100.000				
6.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	3.2241E 06	419.56	40.20	59.76	0.03	10.91	0.	530.47				
						79.092	7.579	11.266	0.006	2.056	0.	100.000				
6.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	1.3505E 04	403.66	47.88	51.55	0.57	43.24	0.	546.90				
						73.809	8.755	9.425	0.104	7.906	0.	100.000				
6.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	2.6790E 02	373.39	60.96	34.35	4.70	107.92	0.	581.31				
						64.233	10.486	5.909	0.808	18.564	0.	100.000				
6.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	2.0252E 01	342.42	69.34	11.75	18.91	134.08	0.	626.49				
						54.656	11.068	1.876	3.018	29.382	0.	100.000				
6.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	6.1508E 00	336.31	64.97	1.27	33.76	211.14	0.	647.45				
						51.943	10.034	0.197	5.214	32.611	0.	100.000				
6.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	3.6489E 00	342.51	57.60	0.11	42.28	207.26	0.	649.77				
						52.712	8.865	0.018	6.507	31.898	0.	100.000				
6.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	2.3455E 00	348.71	51.31	0.01	48.68	201.26	0.	649.97				
						53.650	7.894	0.002	7.489	30.965	0.	100.000				
6.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	1.7246E 00	353.85	46.15	0.00	53.84	196.15	0.	650.00				
						54.439	7.101	0.000	8.284	30.177	0.	100.000				
6.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	1.3537E 00	357.99	42.01	0.00	57.98	192.01	0.	650.00				
						55.075	6.464	0.000	8.921	29.541	0.	100.000				
12.0000	400.00	7.9414E-12	2.0711E 02	4.00007E 09	9.2191E 09	424.51	37.75	62.25	0.03	0.98	0.	525.49				
						80.783	7.183	11.847	0.000	0.187	0.	100.000				
12.0000	600.00	2.1990E-07	3.1479E 01	1.0438E 06	3.2454E 06	421.12	39.43	60.55	0.02	7.78	0.	528.90				
						79.622	7.455	11.448	0.004	1.471	0.	100.000				
12.0000	800.00	2.6585E-04	9.0223E 00	3.7690E 03	1.3724E 04	409.43	45.09	54.52	0.38	31.53	0.	540.96				
						75.686	8.336	10.079	0.071	5.828	0.	100.000				
12.0000	1000.00	4.9018E-02	3.7523E 00	6.4774E 01	2.6436E 02	385.56	55.64	41.20	3.16	82.04	0.	567.60				
						67.928	9.803	7.259	0.556	14.454	0.	100.000				
12.0000	1200.00	2.6875E 00	1.9714E 00	3.0042E 00	1.6357E 01	355.60	65.09	20.70	14.21	153.00	0.	608.60				
						58.429	10.696	3.401	2.334	25.139	0.	100.000				
12.0000	1400.00	6.3697E 01	1.2081E 00	2.7306E-01	3.6449E 00	339.93	64.26	4.18	31.56	201.71	0.	641.63				
						52.978	10.015	0.652	4.919	31.436	0.	100.000				
12.0000	1600.00	8.2139E 02	8.2439E-01	4.0069E-02	1.7657E 00	342.89	57.56	0.45	41.99	206.22	0.	649.11				
						52.824	8.868	0.069	6.469	31.770	0.	100.000				
12.0000	1800.00	6.7984E 03	6.0833E-01	8.3445E-03	1.1745E 01	348.75	51.30	0.06	48.64	201.13	0.	649.89				
						53.664	7.894	0.009	7.484	30.949	0.	100.000				
12.0000	2000.00	4.0014E 04	4.7516E-01	2.2622E-03	8.6253E 01	353.86	46.15	0.01	53.84	196.12	0.	649.98				
						54.441	7.101	0.002	8.283	30.174	0.	100.000				
12.0000	2200.00	1.8036E 05	3.8864E-01	7.5373E-04	6.7690E 01	357.99	42.01	0.00	57.98	192.01	0.	650.00				
						55.075	6.464	0.000	8.921	29.540	0.	100.000				

FIGURE F-1

EFFECT OF TEMPERATURE AND STEAM/CARBON RATIO ON
HYDROGEN YIELD FROM C_9H_{20} HYDROCARBONS

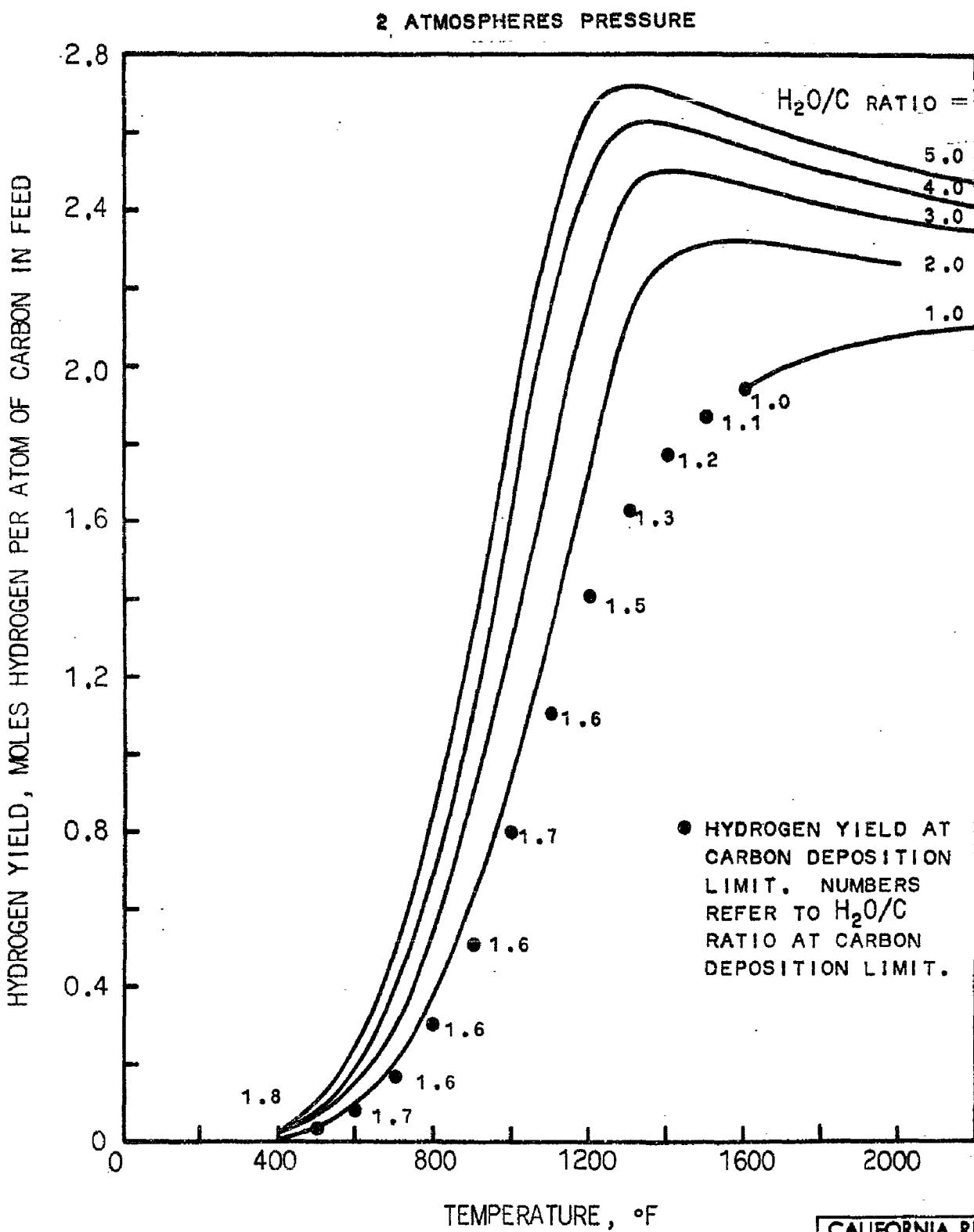
1 ATMOSPHERE PRESSURE



● HYDROGEN YIELD AT
CARBON DEPOSITION
LIMIT. NUMBERS
REFER TO H_2O/C RATIO
AT CARBON DEPOSITION
LIMIT.

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FIGURE F-2
EFFECT OF TEMPERATURE AND STEAM/CARBON RATIO ON
HYDROGEN YIELD FROM C_9H_{20} HYDROCARBONS



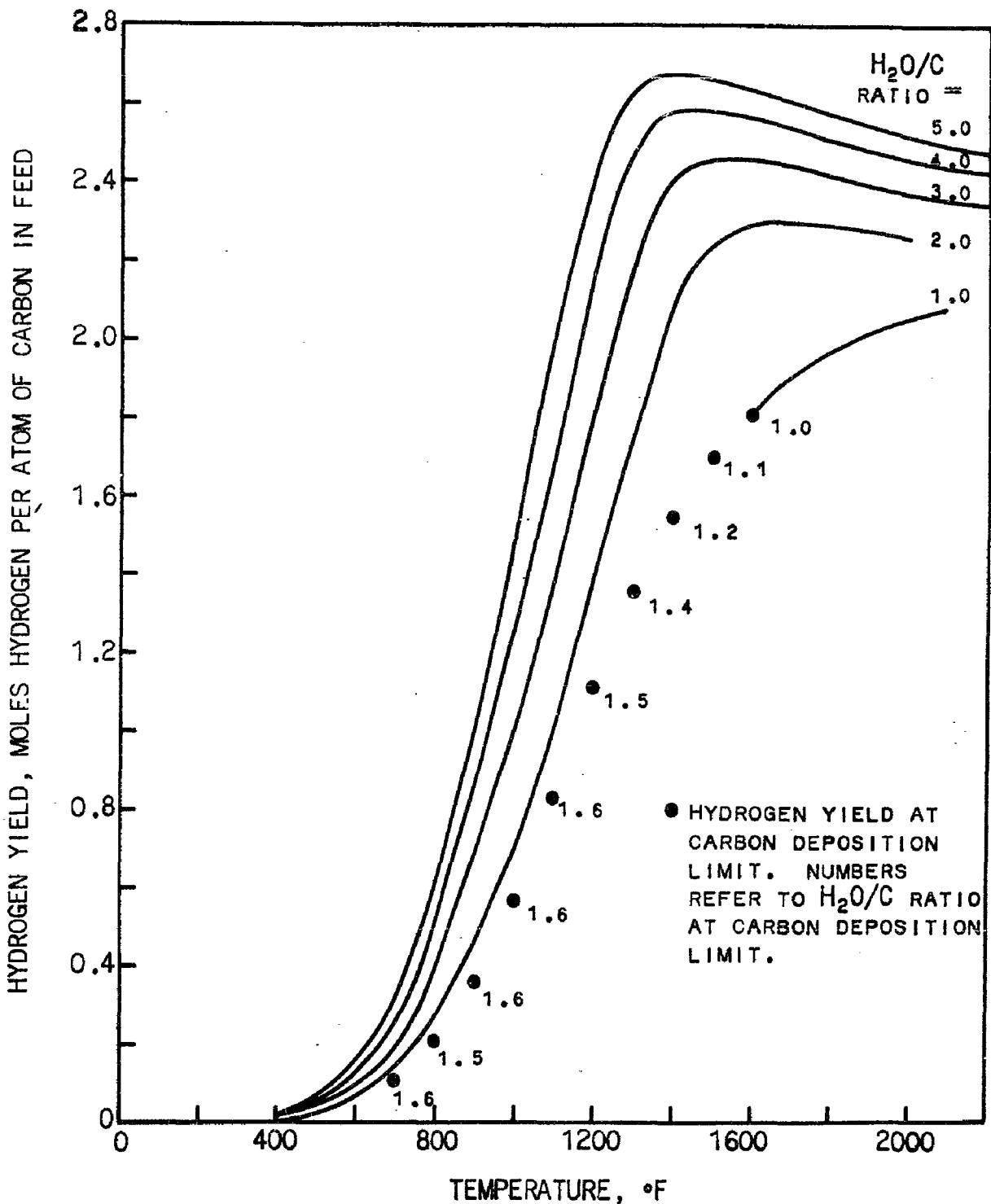
CALIFORNIA RESEARCH
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RICHMOND, CALIFORNIA

MJS RE 647528

FIGURE F-3

EFFECT OF TEMPERATURE AND STEAM/CARBON RATIO ON
HYDROGEN YIELD FROM C_9H_{20} HYDROCARBONS

4 ATMOSPHERES PRESSURE



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F-59

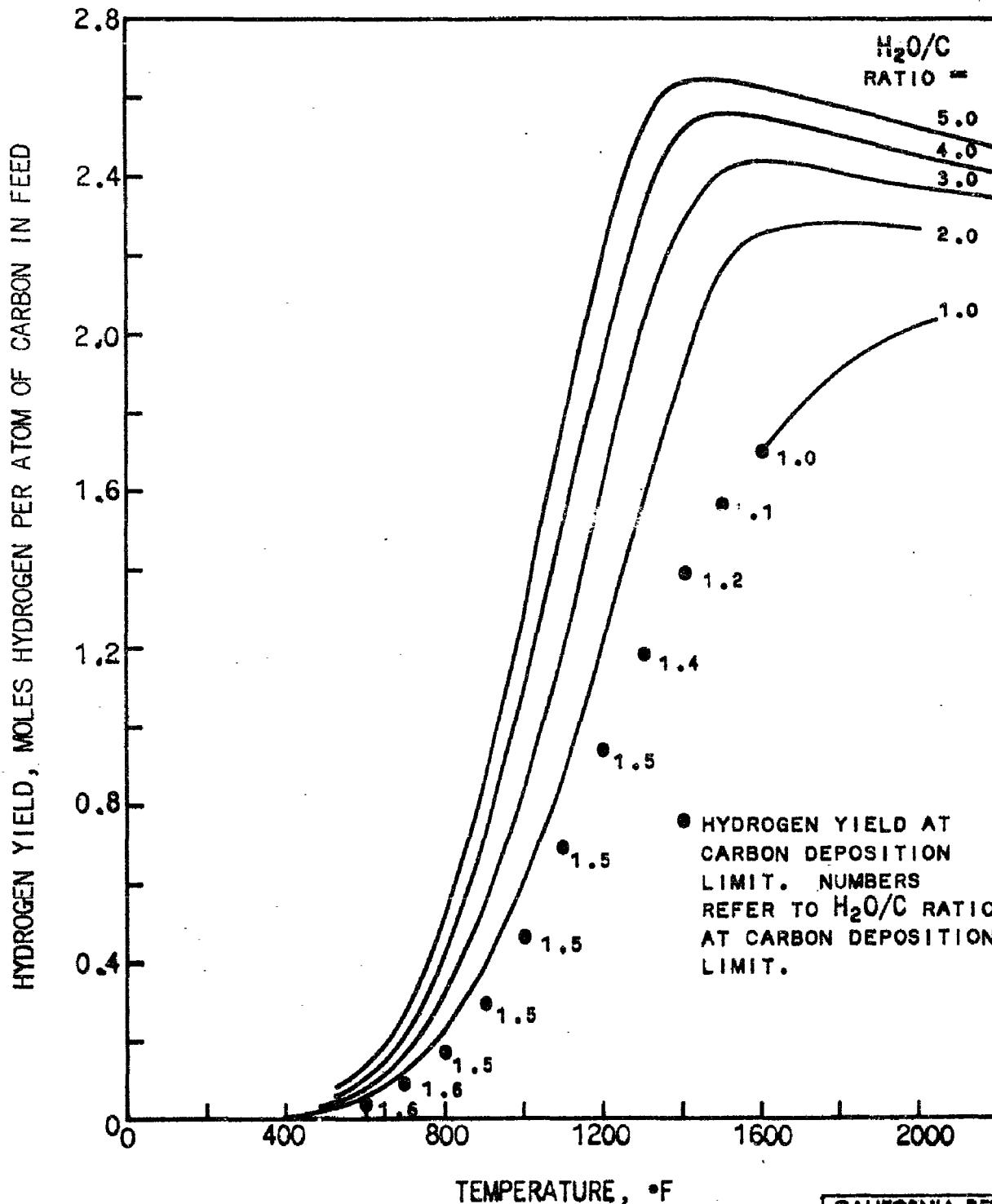
MJS

RE 647529

FIGURE F-4

EFFECT OF TEMPERATURE AND STEAM/CARBON RATIO ON HYDROGEN YIELD FROM C_9H_{20} HYDROCARBONS

6 ATMOSPHERES PRESSURE



● HYDROGEN YIELD AT CARBON DEPOSITION LIMIT. NUMBERS REFER TO H_2O/C RATIO AT CARBON DEPOSITION LIMIT.

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FIGURE F-5

EFFECT OF TEMPERATURE AND STEAM/CARBON RATIO ON
HYDRCGEN YIELD FROM C_9H_{20} HYDROCARBONS

12 ATMOSPHERES PRESSURE

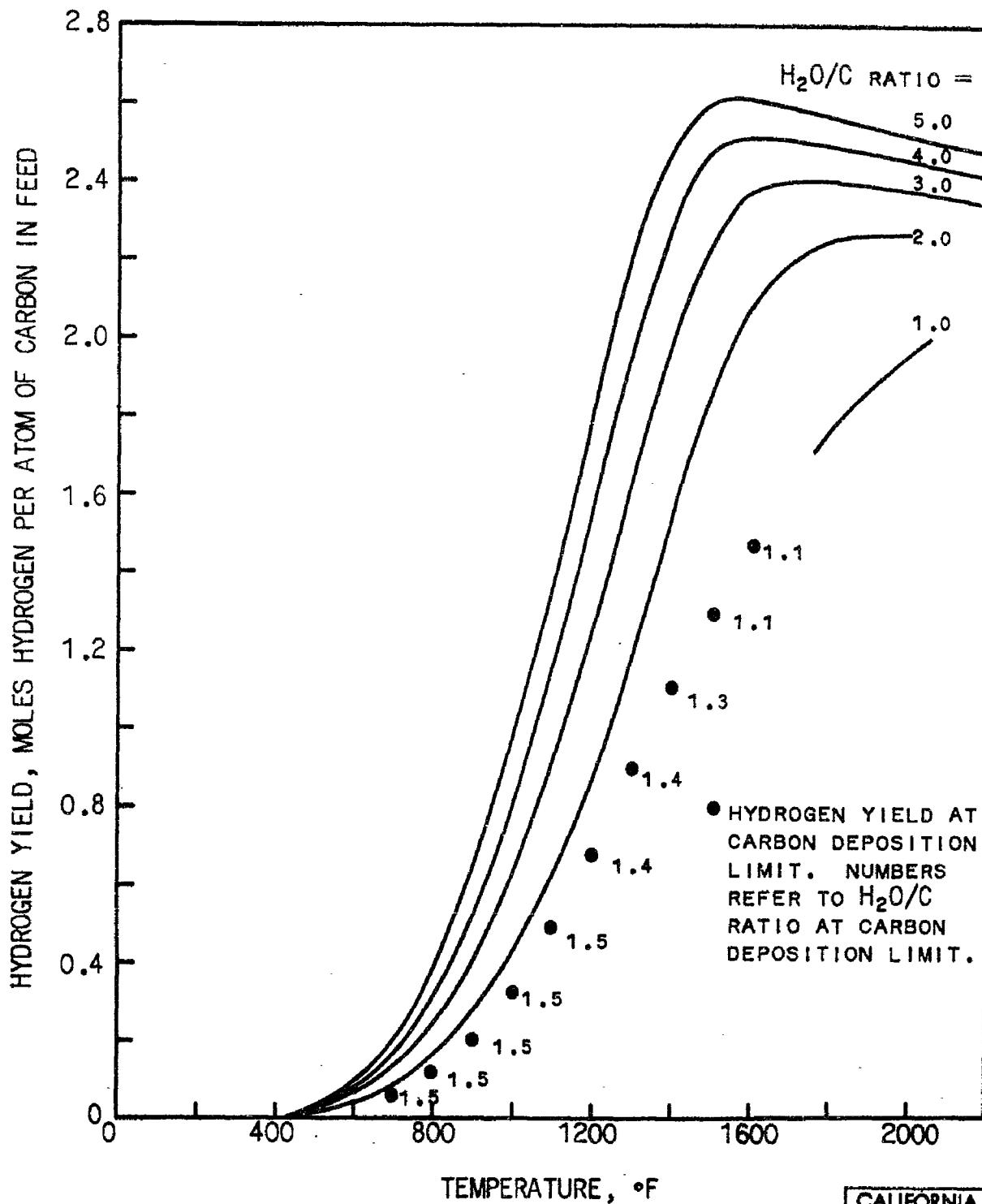


FIGURE F-6

A-F-6

EFFECT OF TEMPERATURE AND STEAM/CARBON RATIO ON
HYDROGEN YIELD FROM CH_4

2 ATMOSPHERES PRESSURE

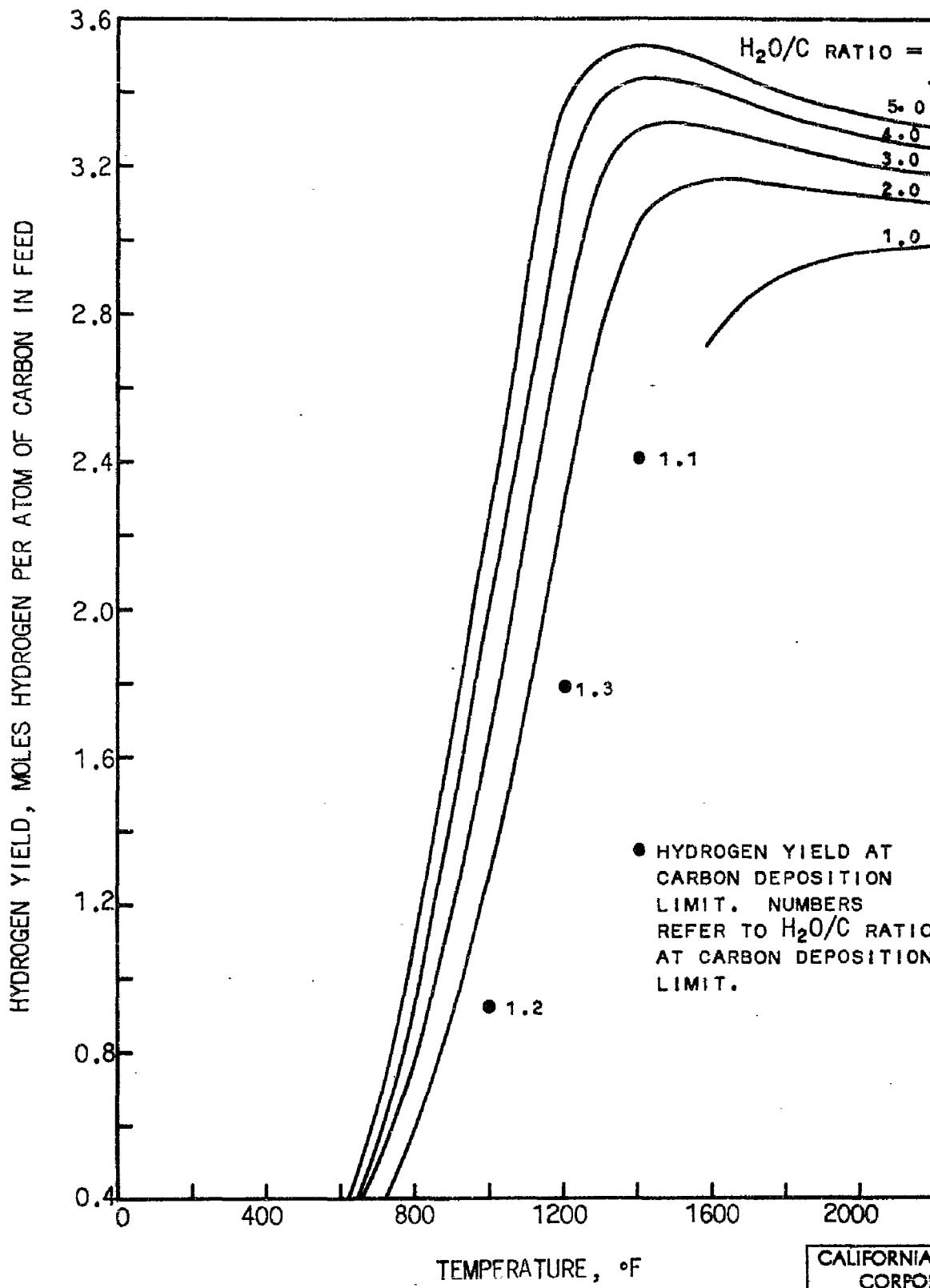
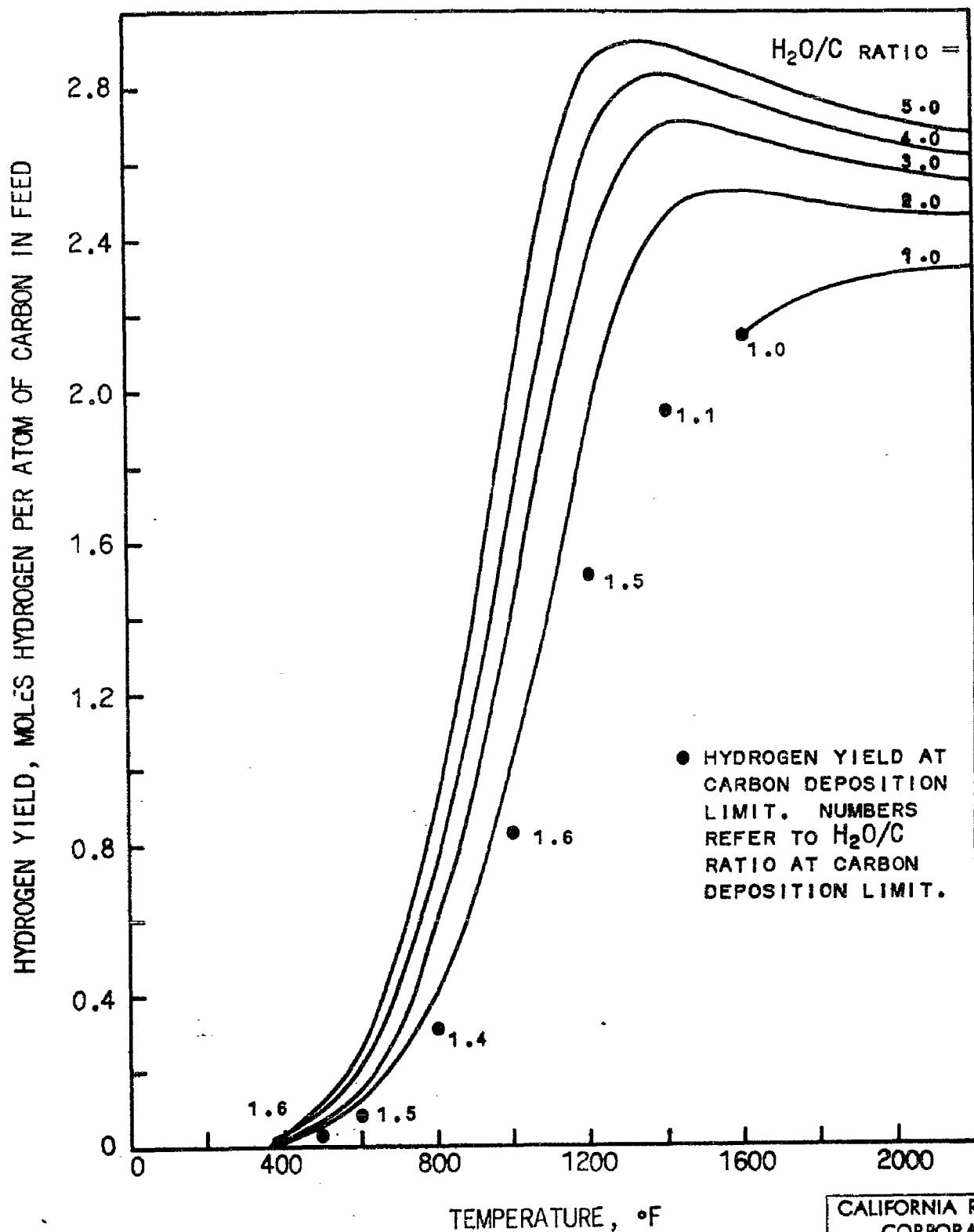


FIGURE F-7

EFFECT OF TEMPERATURE AND STEAM/CARBON RATIO ON
HYDROGEN YIELD FROM C_3H_8

2 ATMOSPHERES PRESSURE

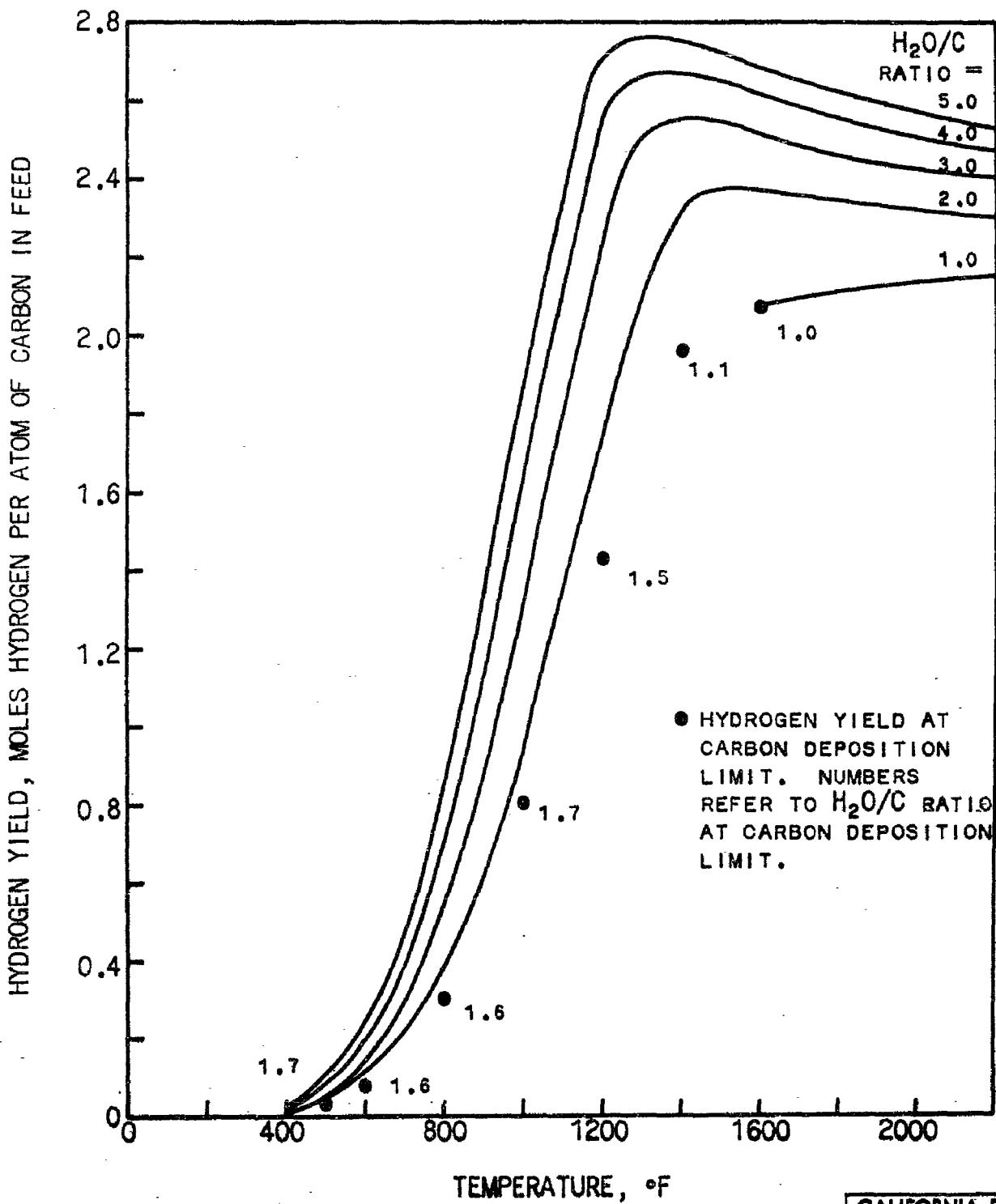


● HYDROGEN YIELD AT
CARBON DEPOSITION
LIMIT. NUMBERS
REFER TO H_2O/C
RATIO AT CARBON
DEPOSITION LIMIT.

FIGURE F-8

EFFECT OF TEMPERATURE AND STEAM/CARBON RATIO ON
HYDROGEN YIELD FROM C_6H_{14} HYDROCARBONS

2 ATMOSPHERES PRESSURE



● HYDROGEN YIELD AT
CARBON DEPOSITION
LIMIT. NUMBERS
REFER TO H_2O/C RATIO
AT CARBON DEPOSITION
LIMIT.

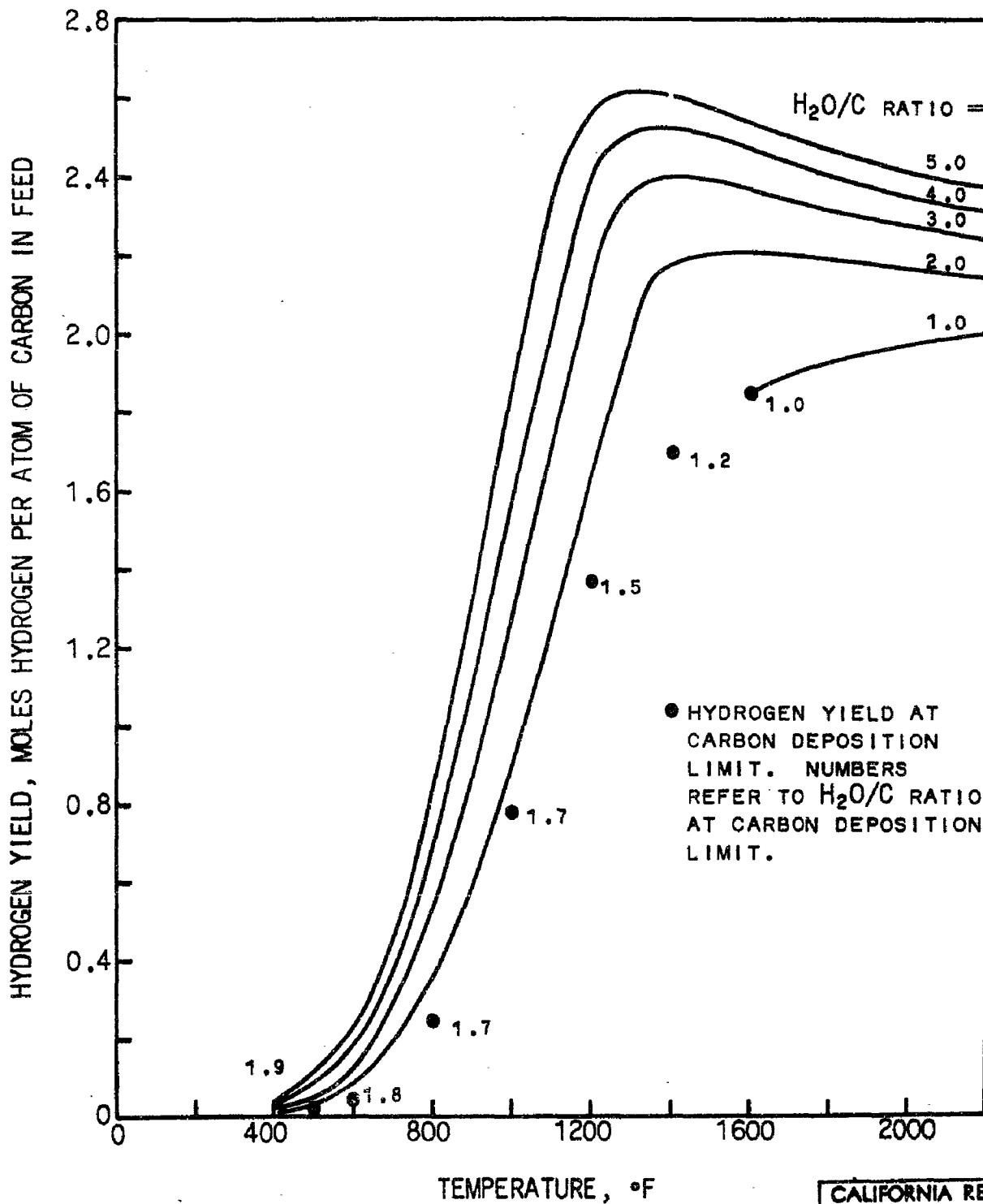
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MJS RE 647534

FIGURE F-9

EFFECT OF TEMPERATURE AND STEAM/CARBON RATIO ON
HYDROGEN YIELD FROM $C_{N_2H_2N}$ HYDROCARBONS

2 ATMOSPHERES PRESSURE



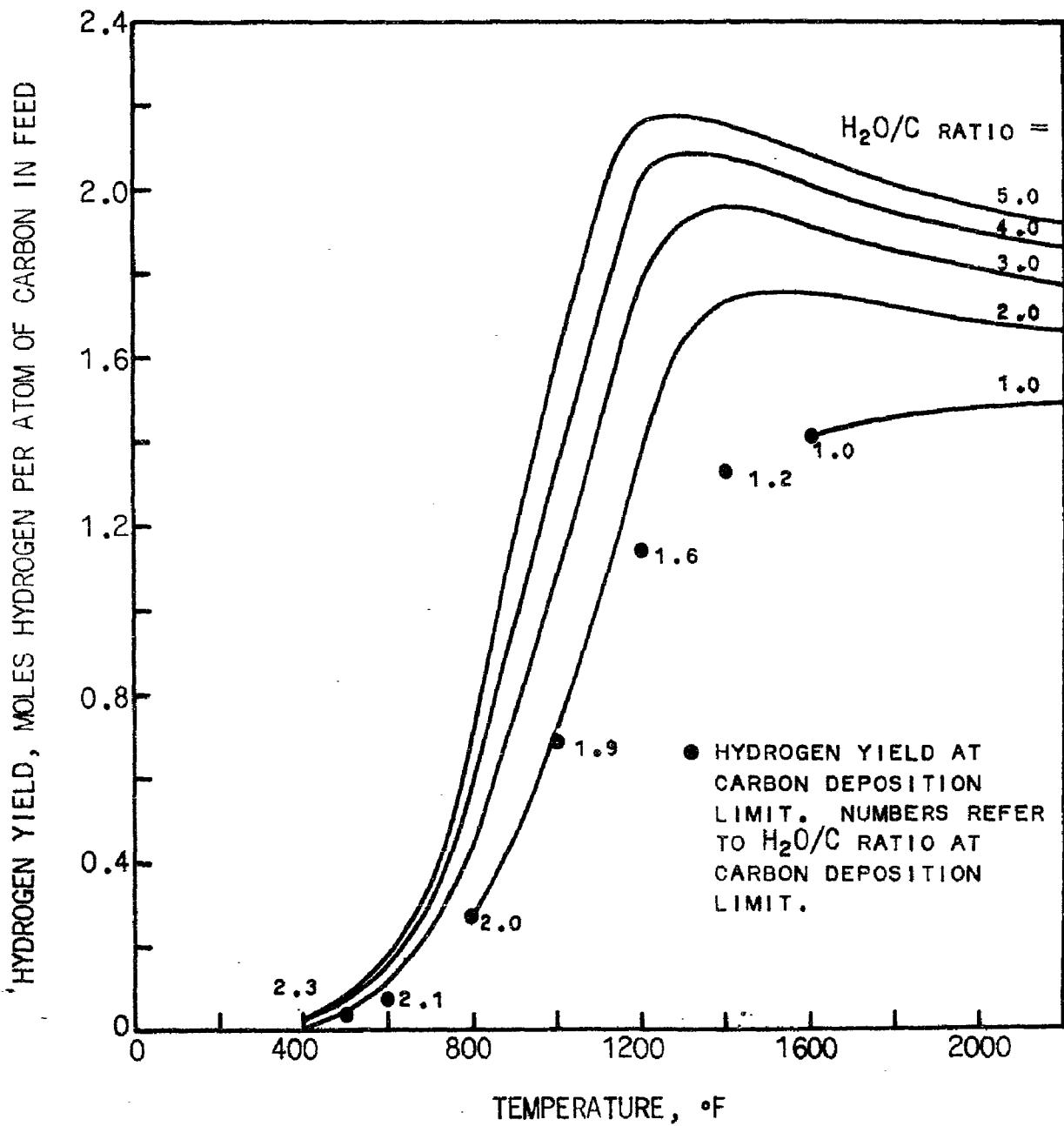
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CORPORATION
RICHMOND, CALIFORNIA

MJS RE 647535

FIGURE F-10

EFFECT OF TEMPERATURE AND STEAM/CARBON RATIO ON
HYDROGEN YIELD FROM $C_{N,H}$ HYDROCARBONS

2 ATMOSPHERES PRESSURE



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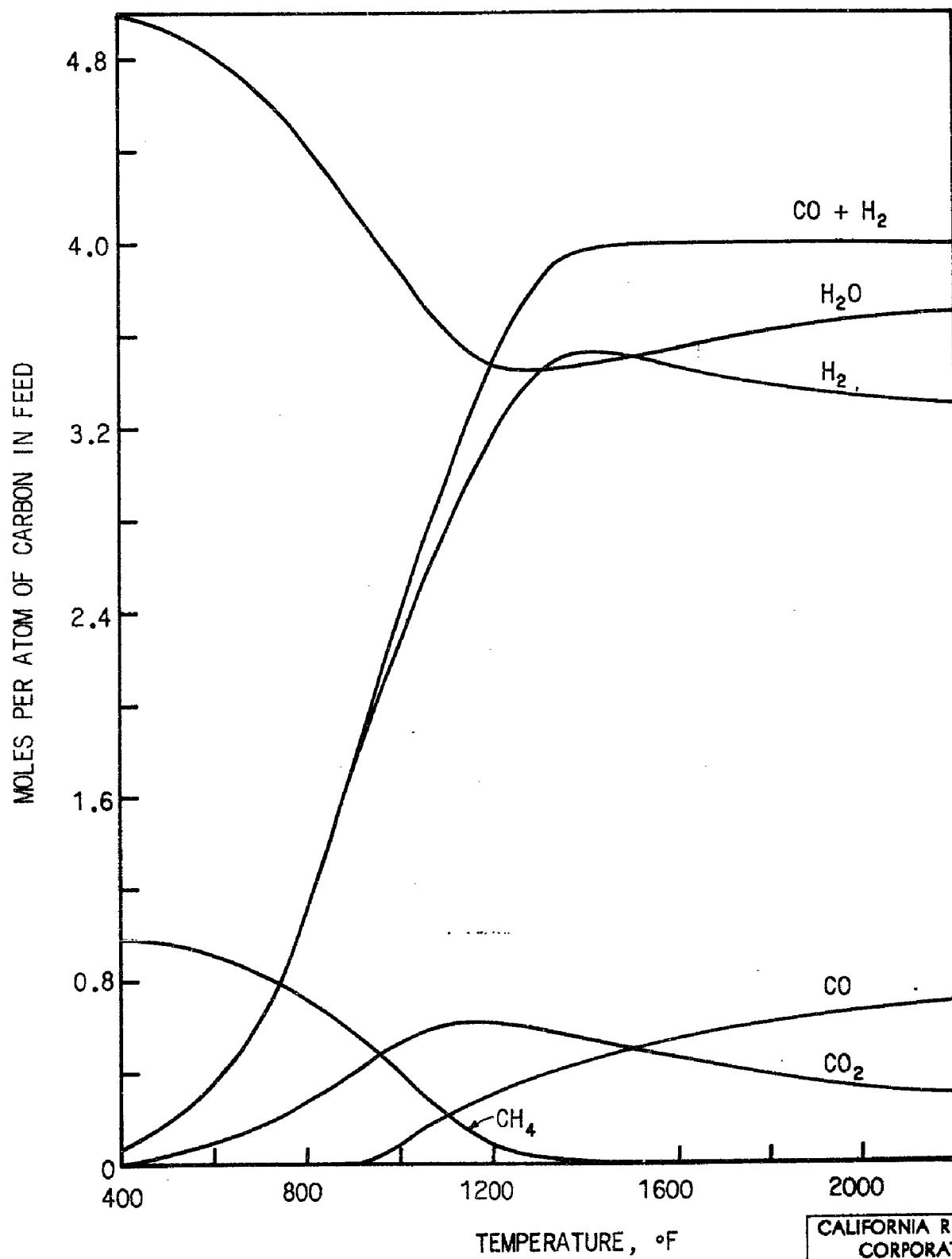
MJS. RE 647536

FIGURE F-11

A-F-11

EFFECT OF TEMPERATURE ON COMPOSITION OF
STEAM REFORMATE FROM CH_4 - STEAM/CARBON RATIO, 5.0

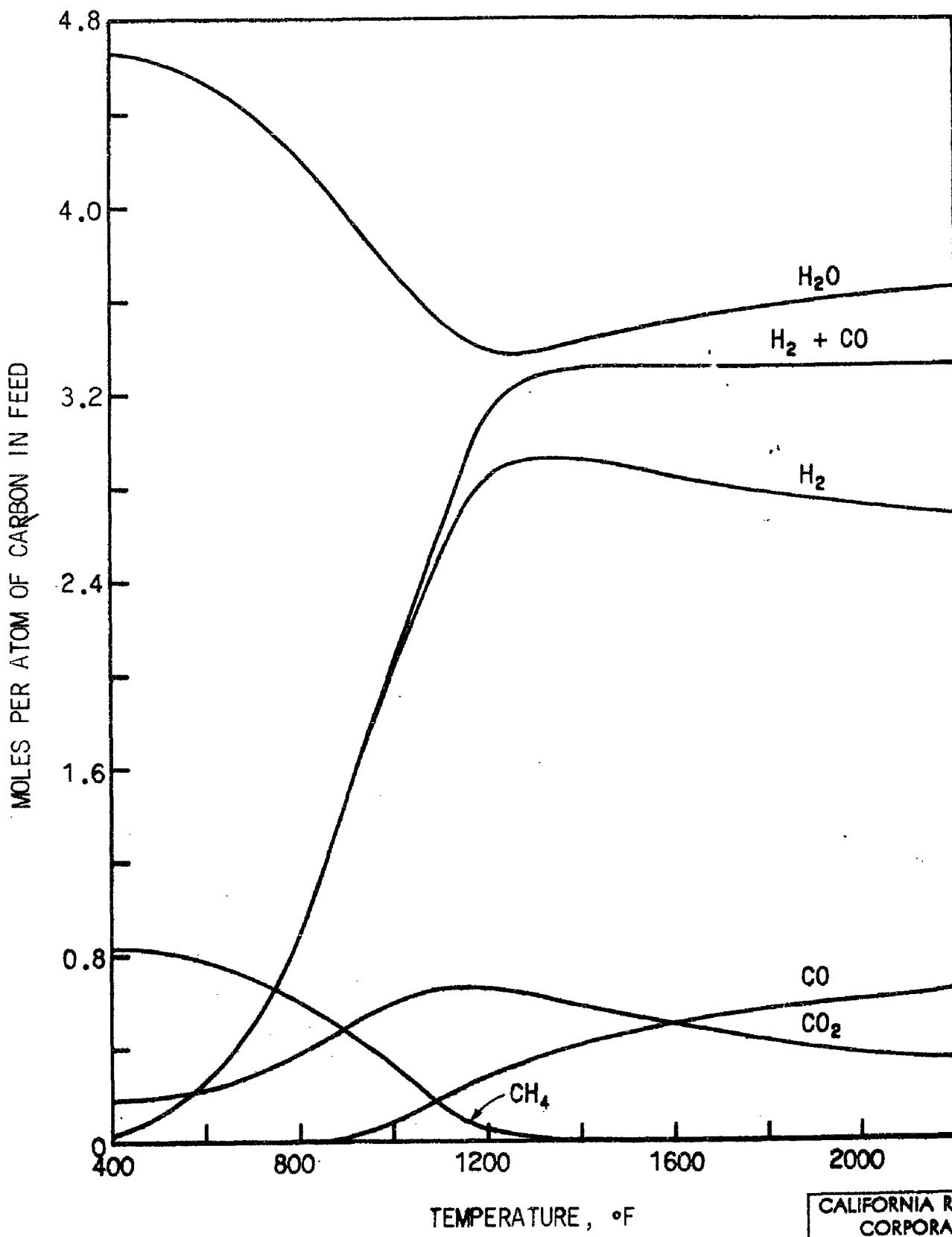
2 ATMOSPHERES PRESSURE



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EFFECT OF TEMPERATURE ON COMPOSITION OF
STEAM REFORMATE FROM C_3H_8 - STEAM/CARBON RATIO, 5.0

2 ATMOSPHERES PRESSURE



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CORPORATION
RICHMOND, CALIFORNIA

MJS

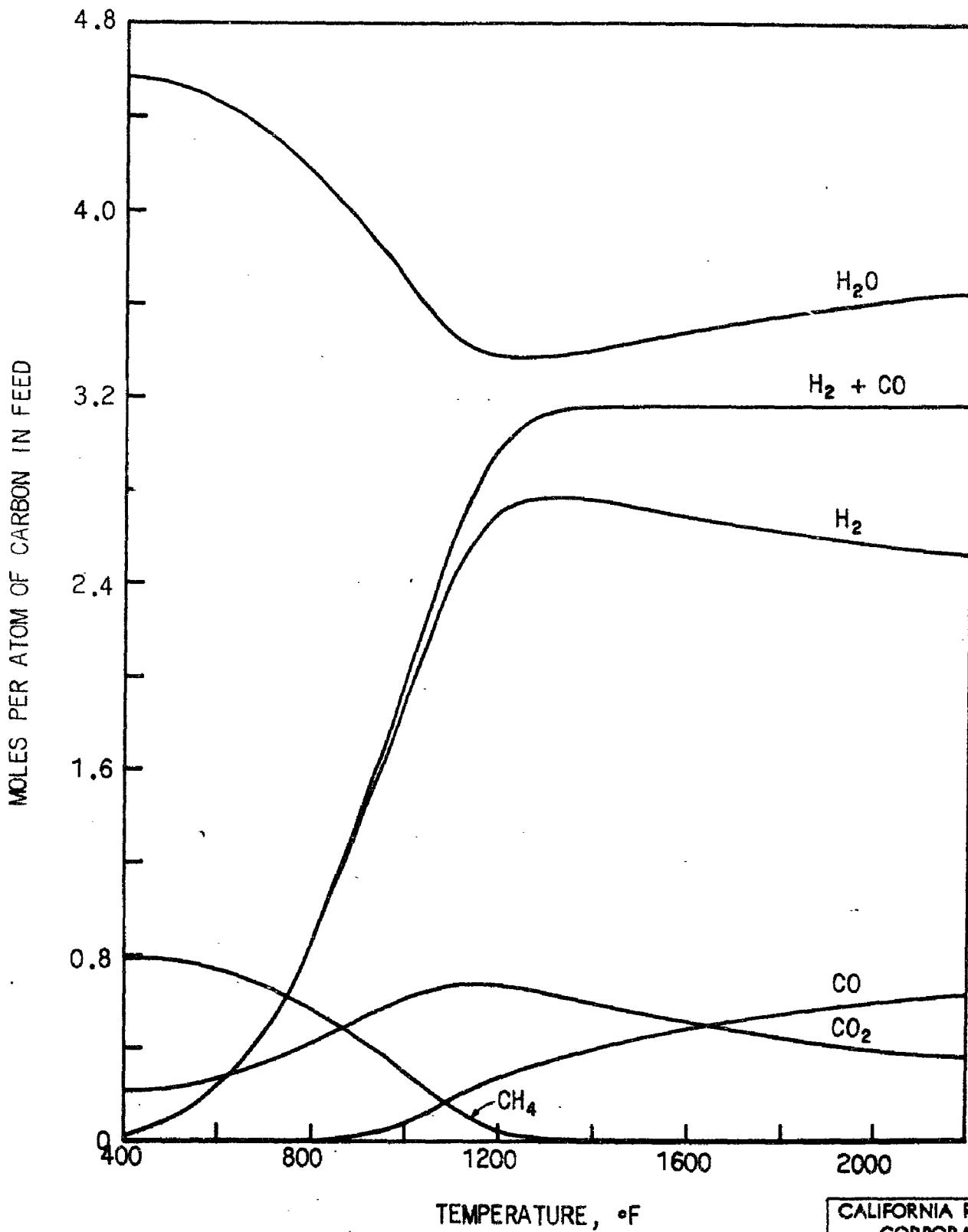
RE 647538

FIGURE F-13

K-113

EFFECT OF TEMPERATURE ON COMPOSITION OF
STEAM REFORMATE FROM C_6H_{14} HYDROCARBONS - STEAM/CARBON RATIO, 5.0

2 ATMOSPHERES PRESSURE

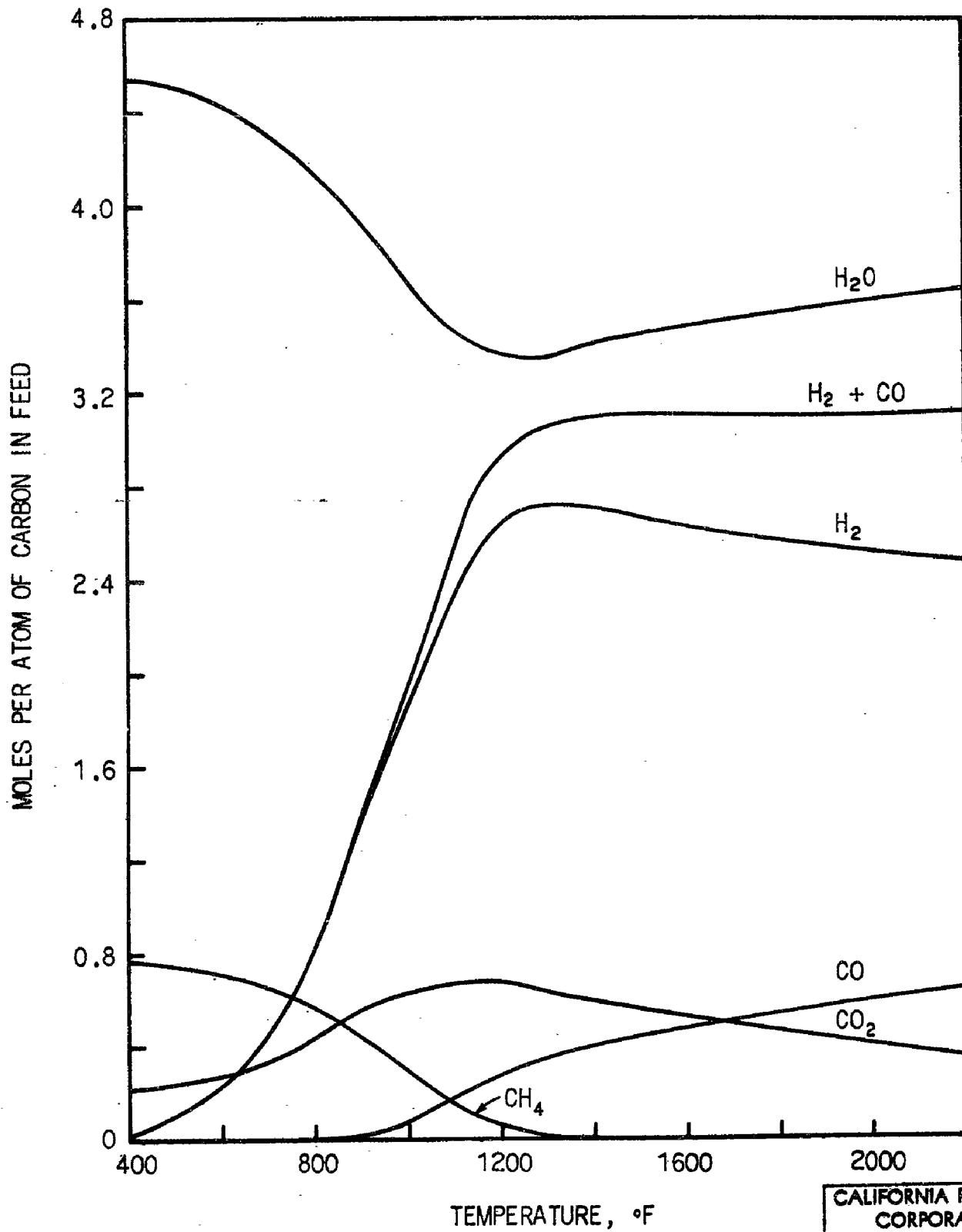


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FIGURE F-14

EFFECT OF TEMPERATURE ON COMPOSITION OF STEAM REFORMATE FROM
 C_9H_{20} HYDROCARBONS - STEAM/CARBON RATIO, 5.0

2 ATMOSPHERES PRESSURE



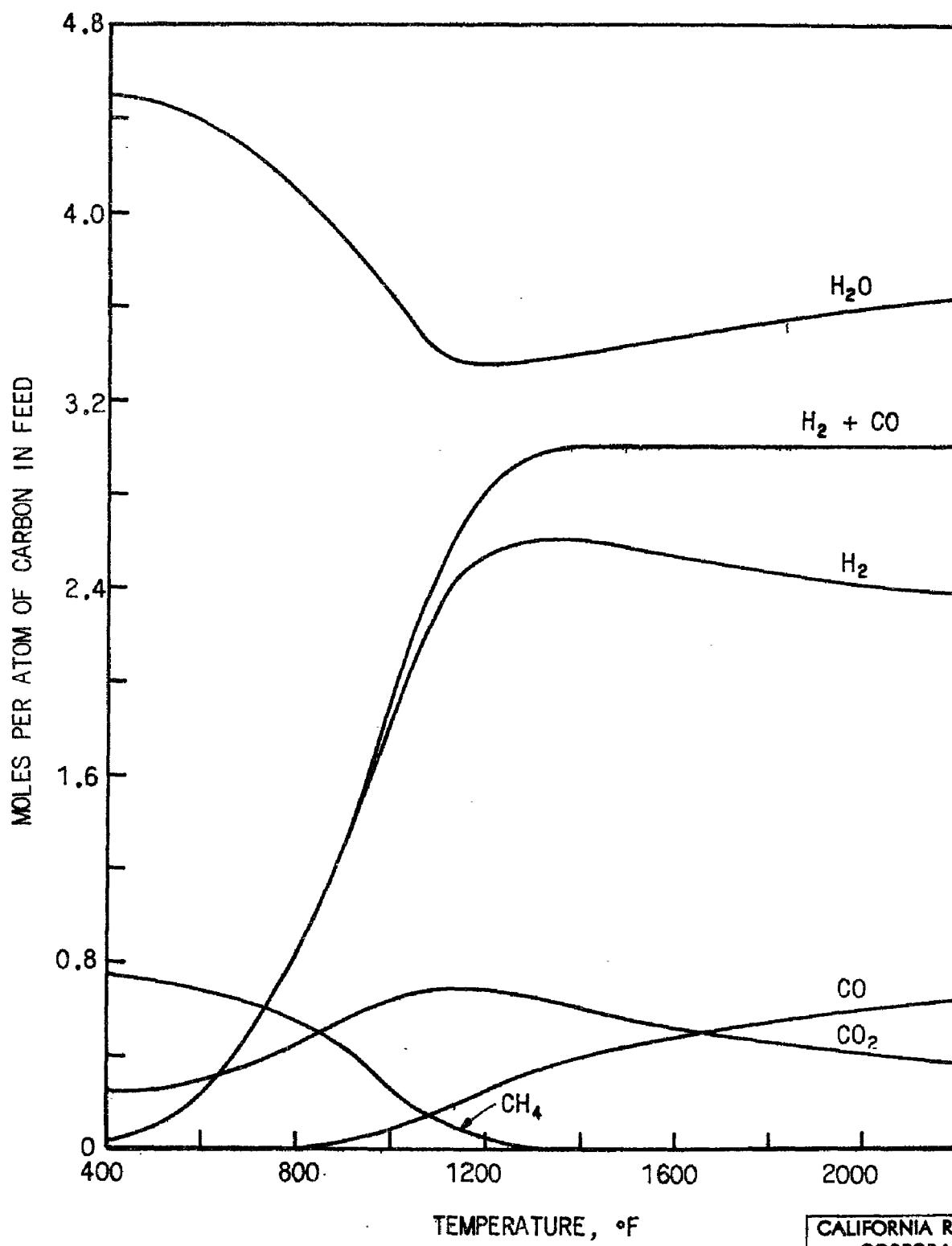
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FIGURE F-15

A-F-15

EFFECT OF TEMPERATURE ON COMPOSITION OF
STEAM REFORMATE FROM $C_{N_2H_2N}$ HYDROCARBONS - STEAM/CARBON RATIO, 5.0

2 ATMOSPHERES PRESSURE

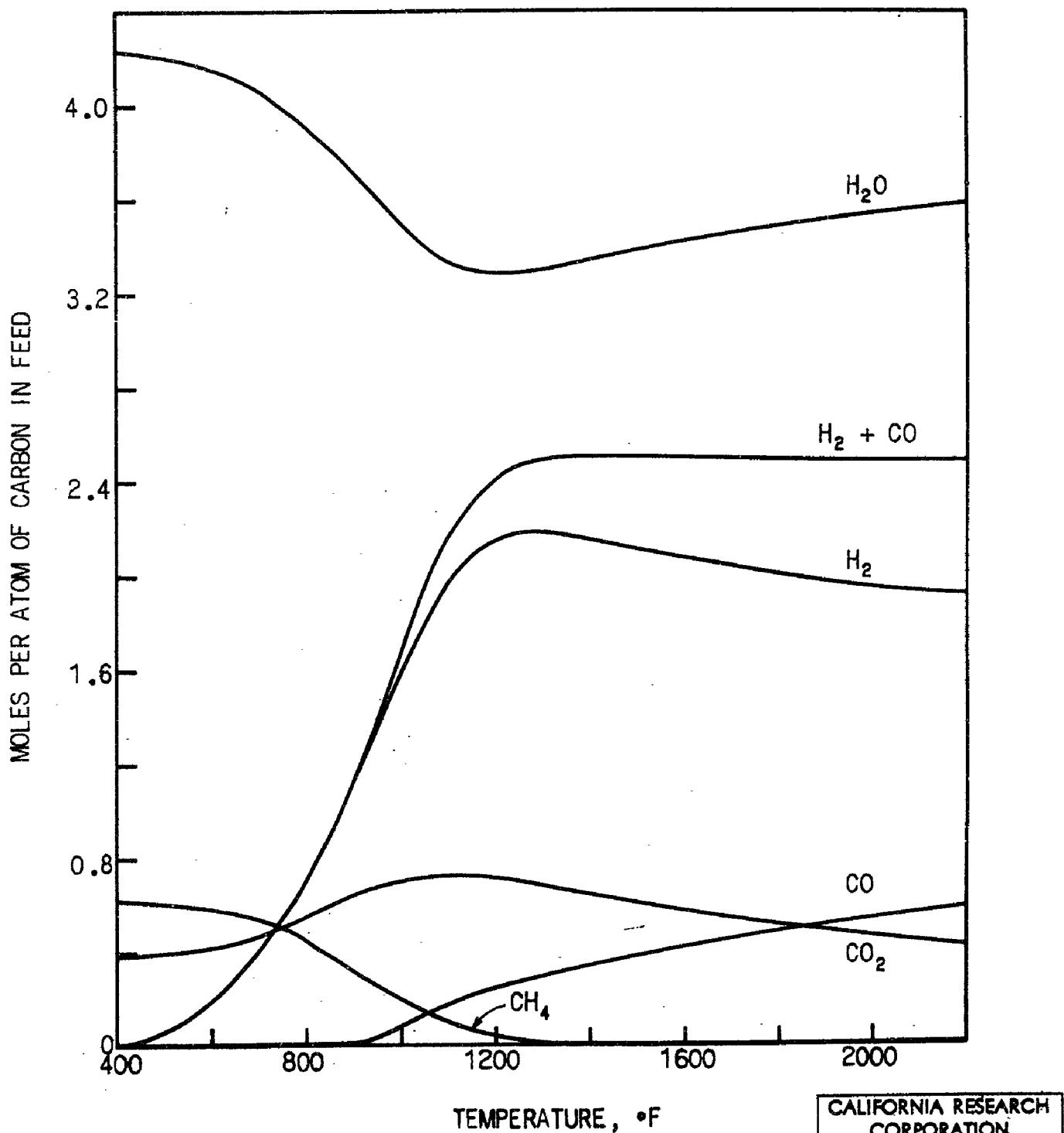


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FIGURE F-16

EFFECT OF TEMPERATURE ON COMPOSITION OF
STEAM REFORMATE FROM C_NH_N HYDROCARBONS - STEAM/CARBON RATIO, 5.0

2 ATMOSPHERES PRESSURE

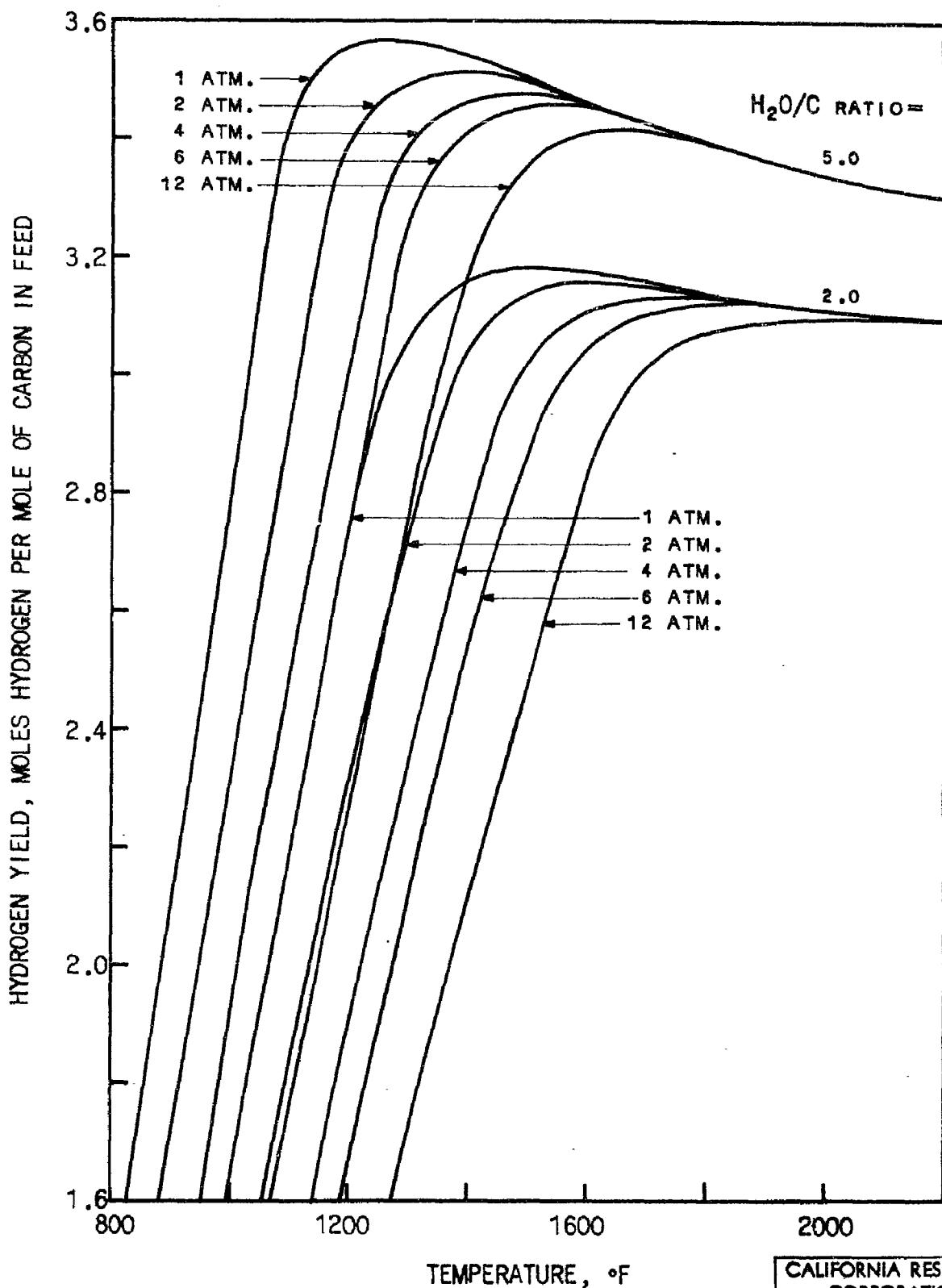


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FIGURE F-17

A-F-17

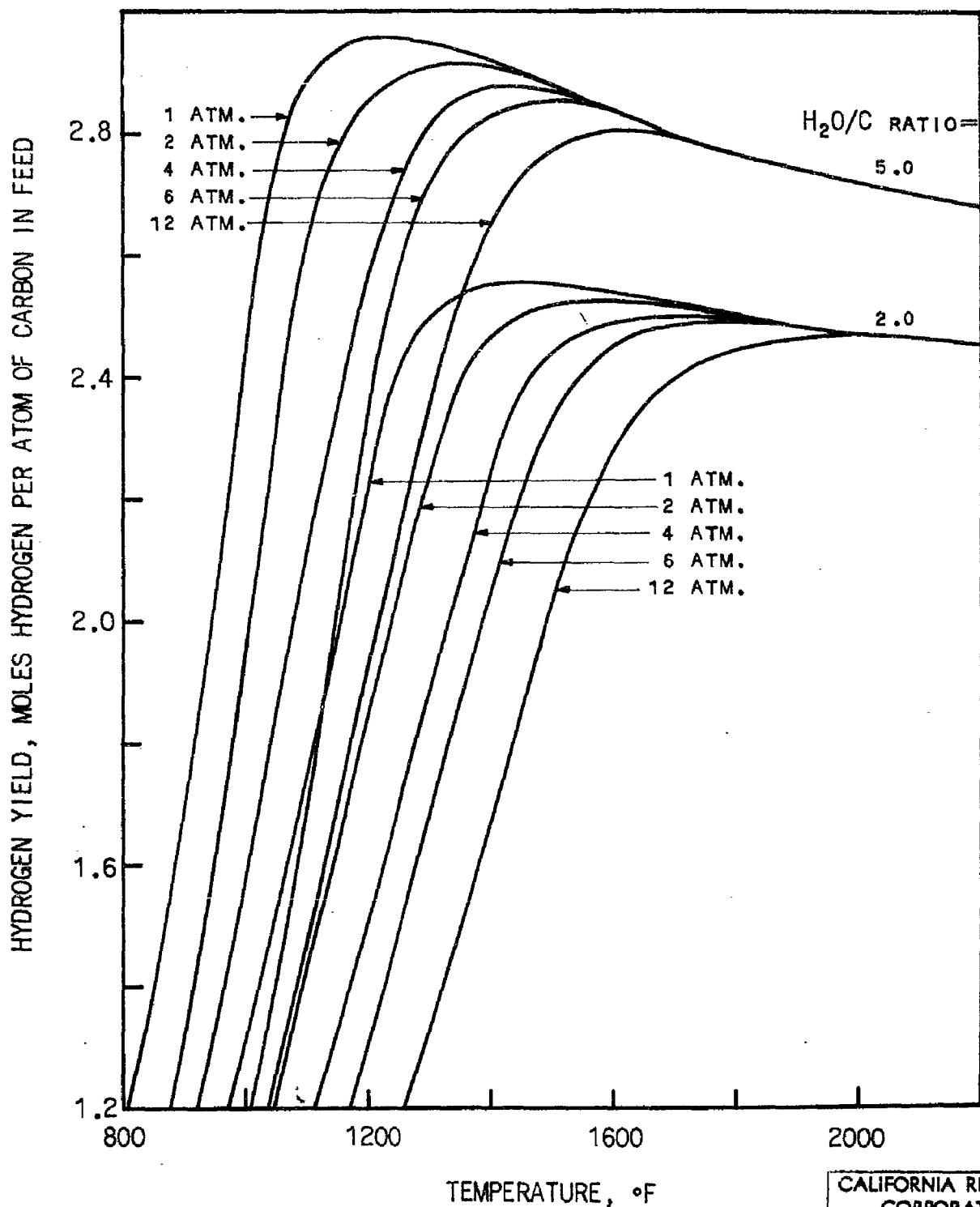
EFFECT OF PRESSURE ON HYDROGEN YIELD FROM CH₄
STEAM/CARBON RATIOS, 2.0 AND 5.0



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FIGURE F-18

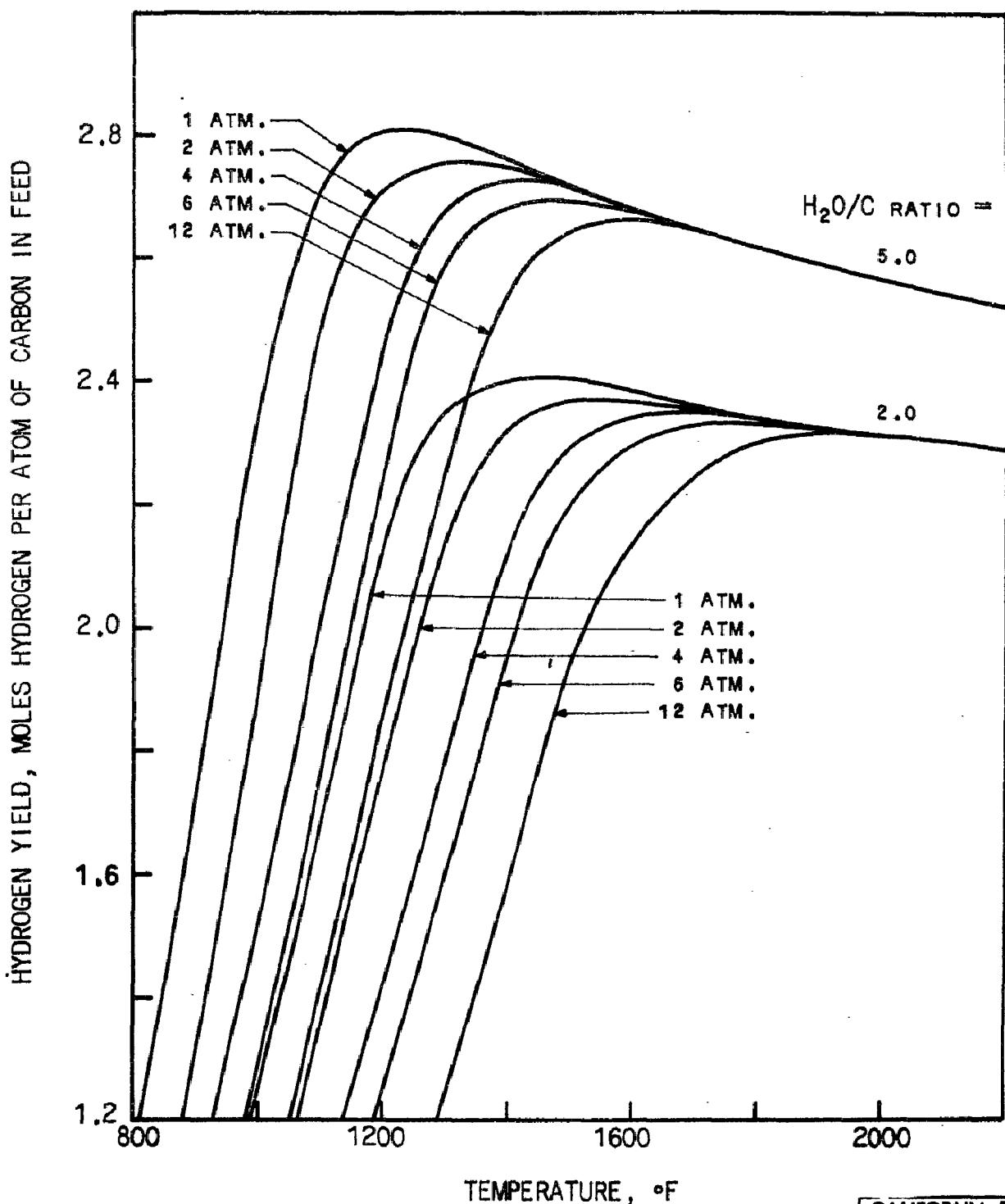
EFFECT OF PRESSURE ON HYDROGEN YIELD FROM C_3H_8
STEAM/CARBON RATIOS, 2.0 AND 5.0



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FIGURE F-19

EFFECT OF PRESSURE ON HYDROGEN YIELD FROM C_6H_{14} HYDROCARBONS
STEAM/CARBON RATIOS, 2.0 AND 5.0



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FIGURE F-20

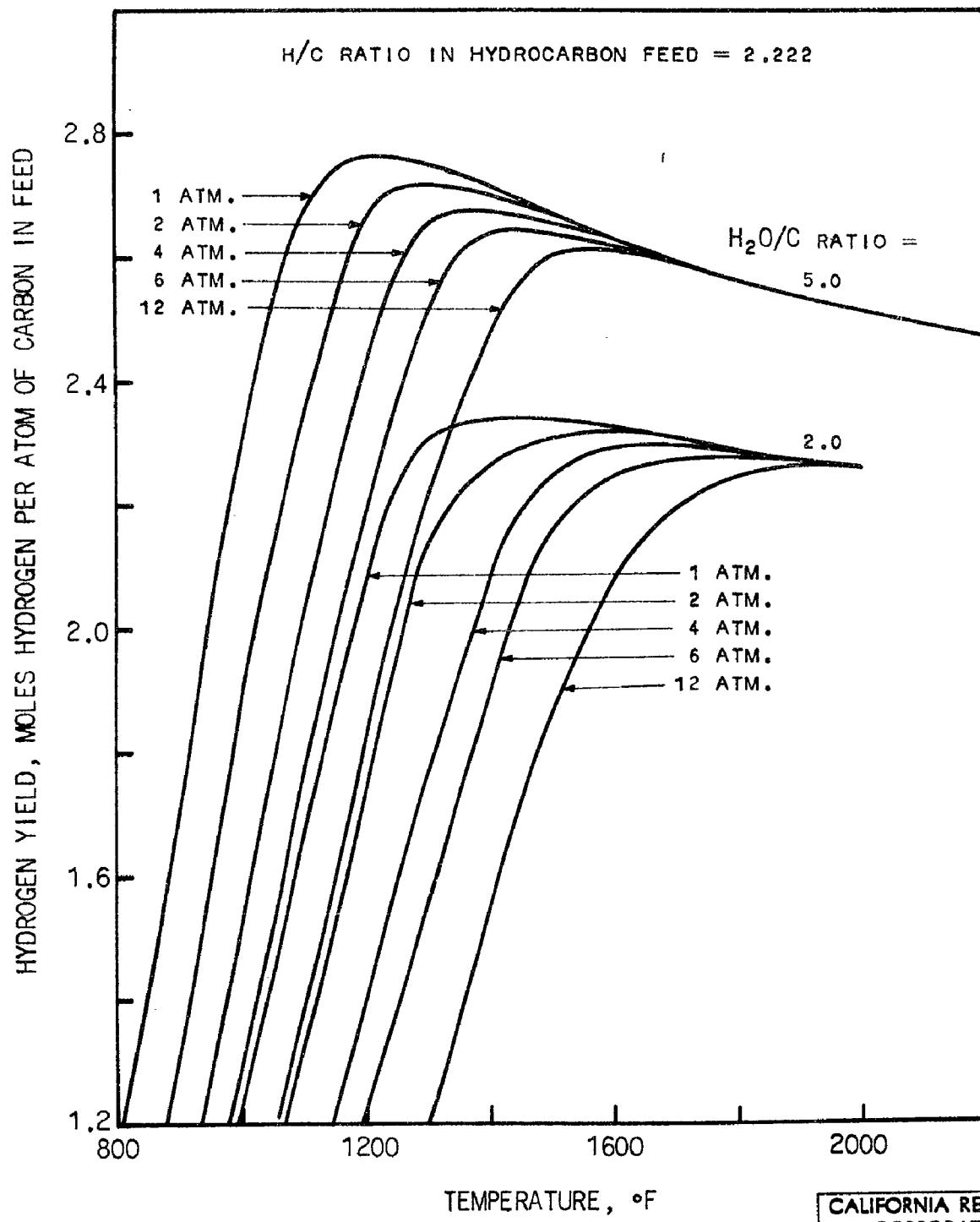
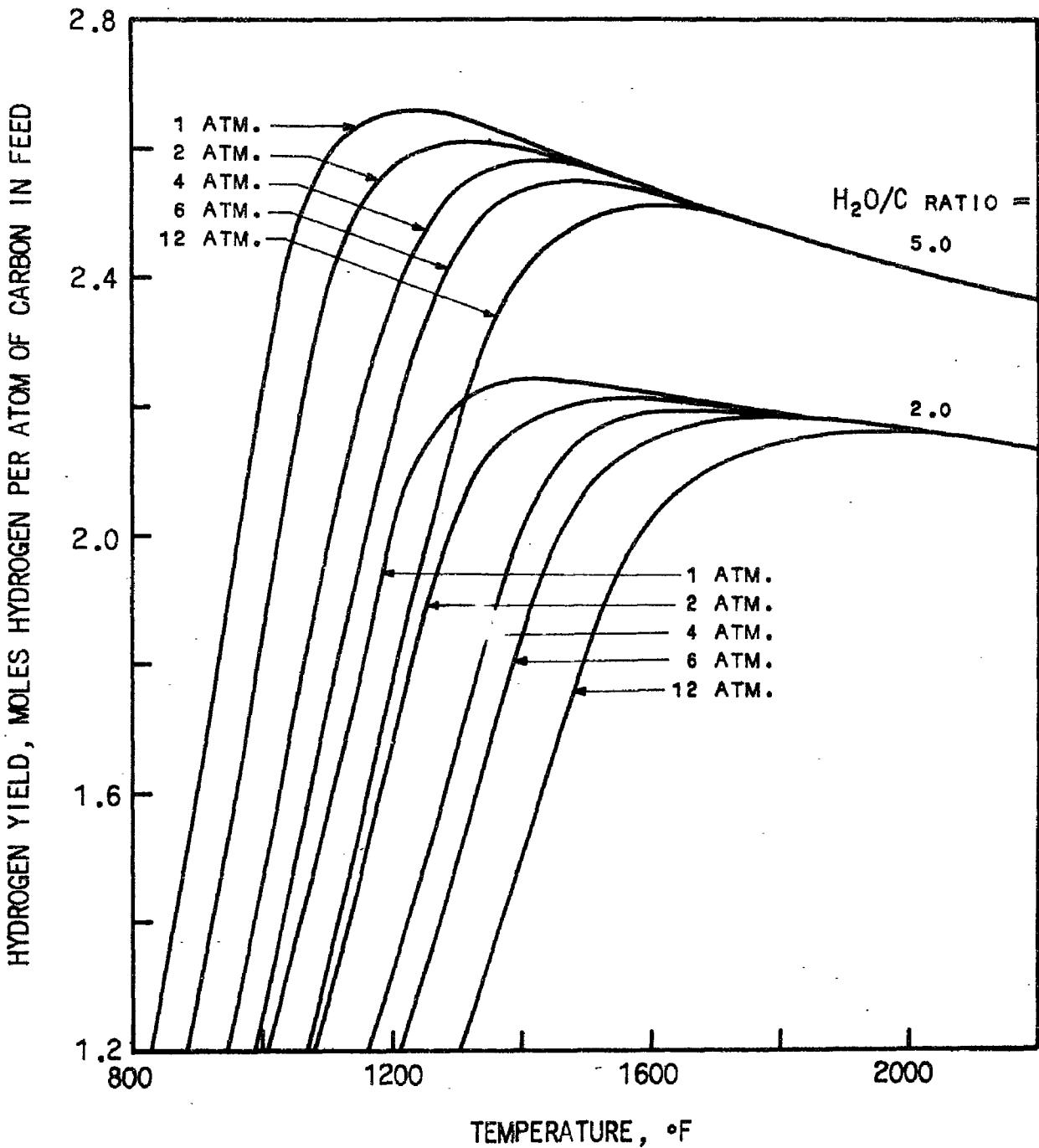
EFFECT OF PRESSURE ON HYDROGEN YIELD FROM
 C_9H_{20} HYDROCARBONS

FIGURE F-21

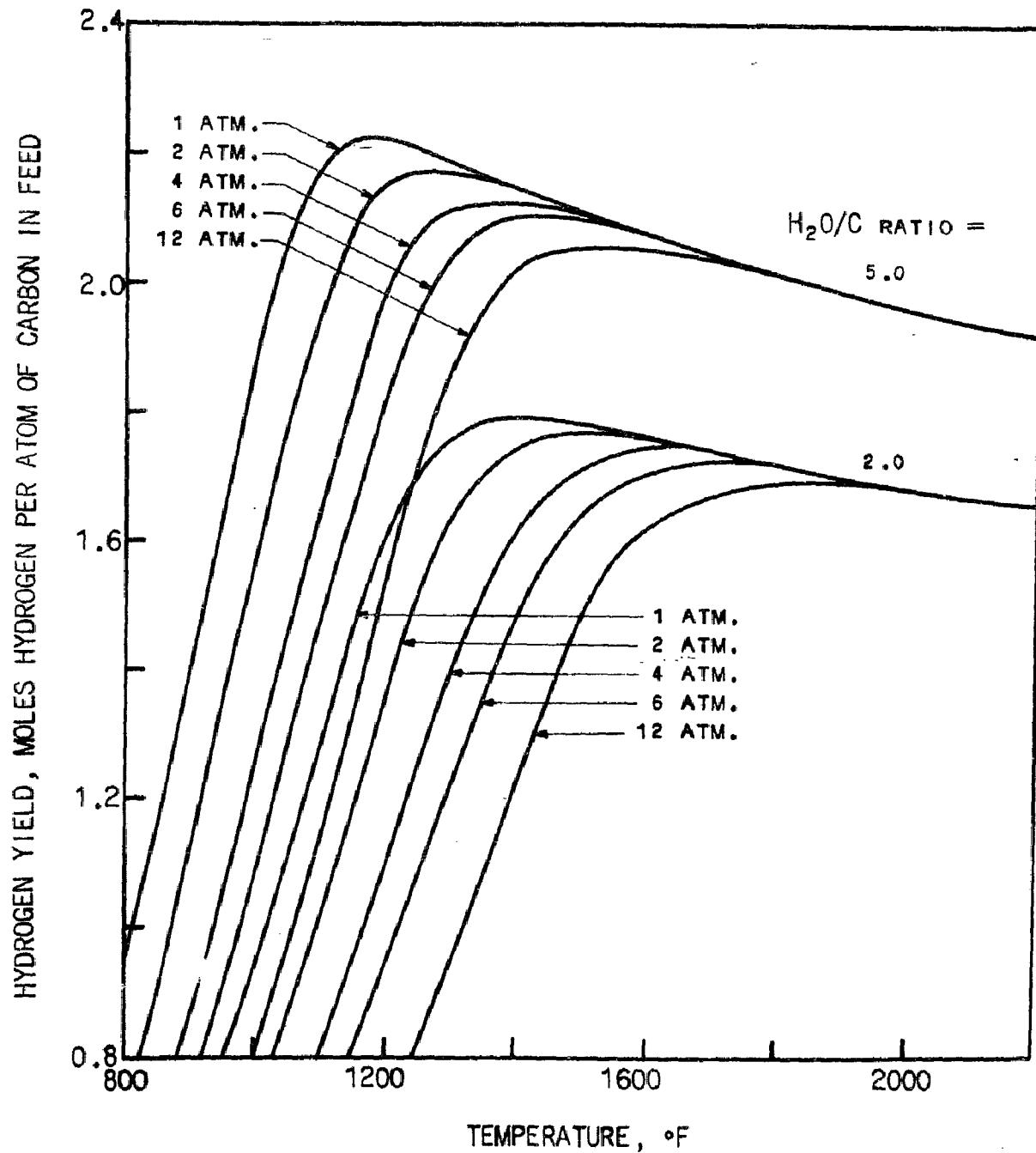
EFFECT OF PRESSURE ON HYDROGEN YIELD FROM C_NH_{2N} HYDROCARBONS
STEAM/CARBON RATIOS, 2.0 AND 5.0



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FIGURE F-22

EFFECT OF PRESSURE ON HYDROGEN YIELD FROM C_nH_n HYDROCARBONS
STEAM/CARBON RATIOS, 2.0 AND 5.0



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A P P E N D I X G

THEORETICAL CARBON DEPOSITION LIMITS IN HYDROCARBON STEAM REFORMING

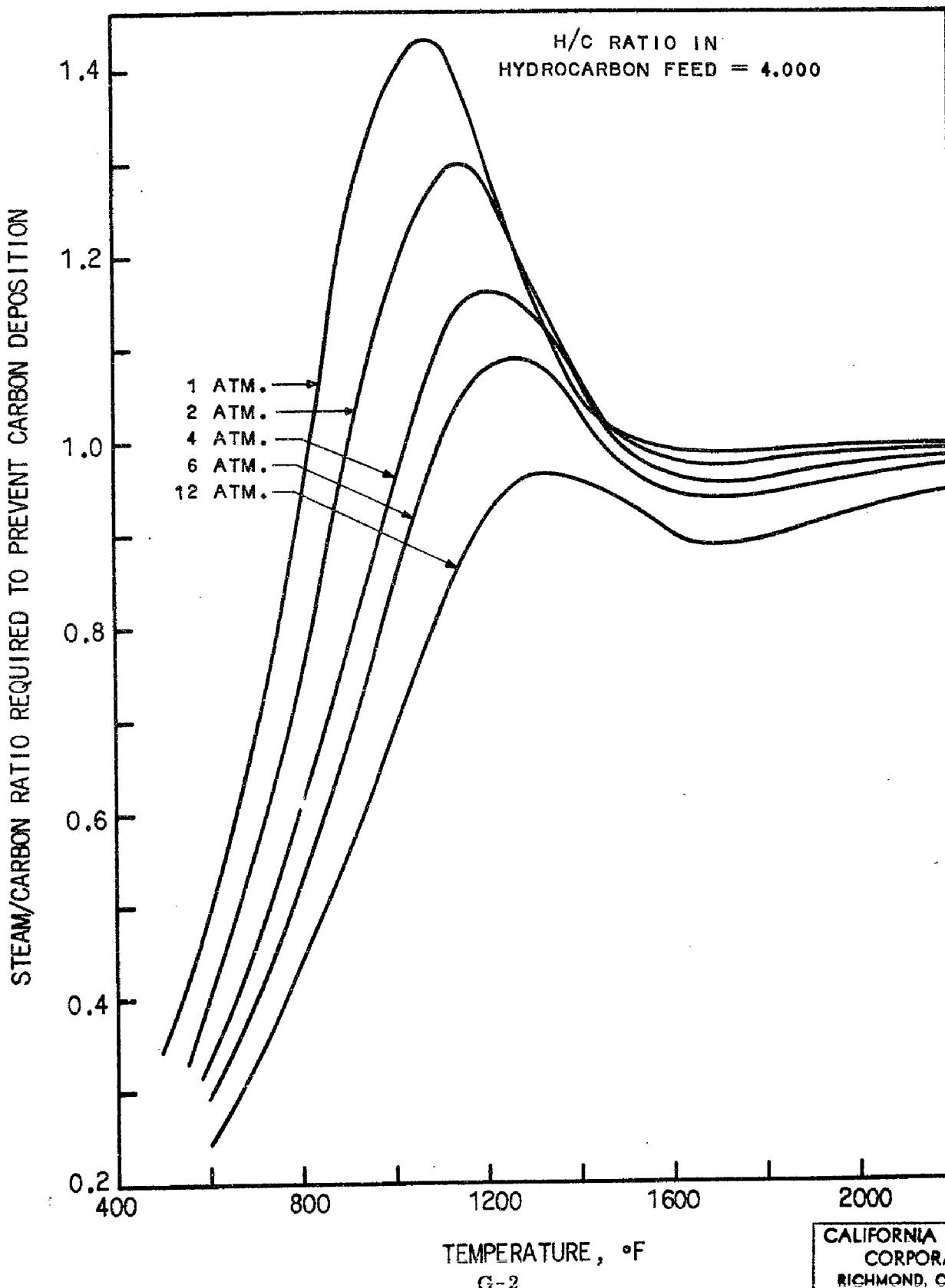
The carbon deposition limits plotted in Appendix Figures G-1 to G-6 were obtained as described in Section X-C. Carbon deposition limits are discussed in Section X-D-1.

:msr

FIGURE G-1

A-E-1

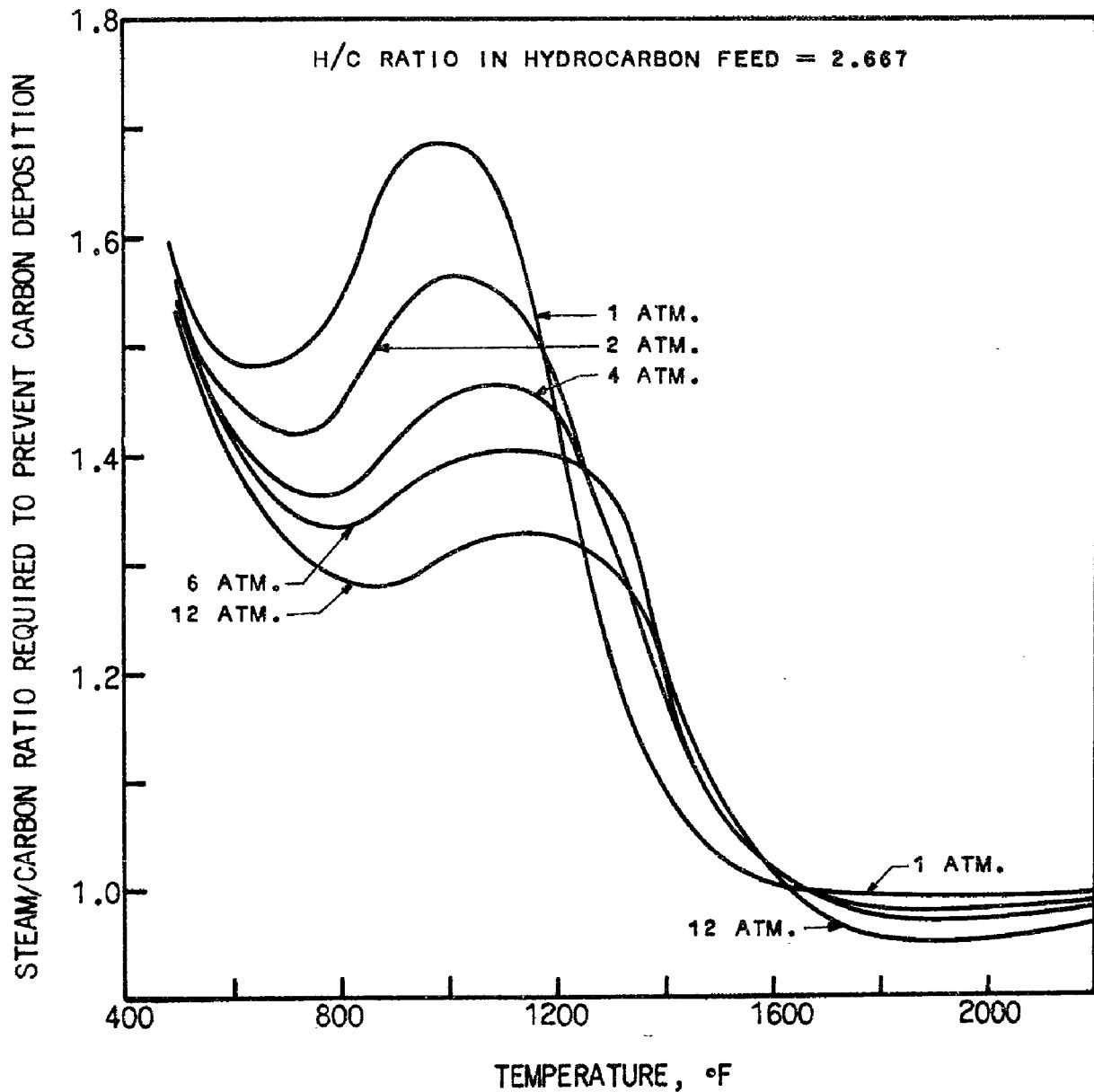
EFFECT OF PRESSURE ON STEAM/CARBON RATIO REQUIRED TO
PREVENT CARBON DEPOSITION FROM CH₄



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FIGURE G-2

EFFECT OF PRESSURE ON STEAM/CARBON RATIO REQUIRED TO PREVENT CARBON DEPOSITION FROM C_3H_8



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FIGURE G-3

EFFECT OF PRESSURE ON STEAM/CARBON RATIO REQUIRED TO PREVENT CARBON DEPOSITION FROM C_6H_{14} HYDROCARBONS

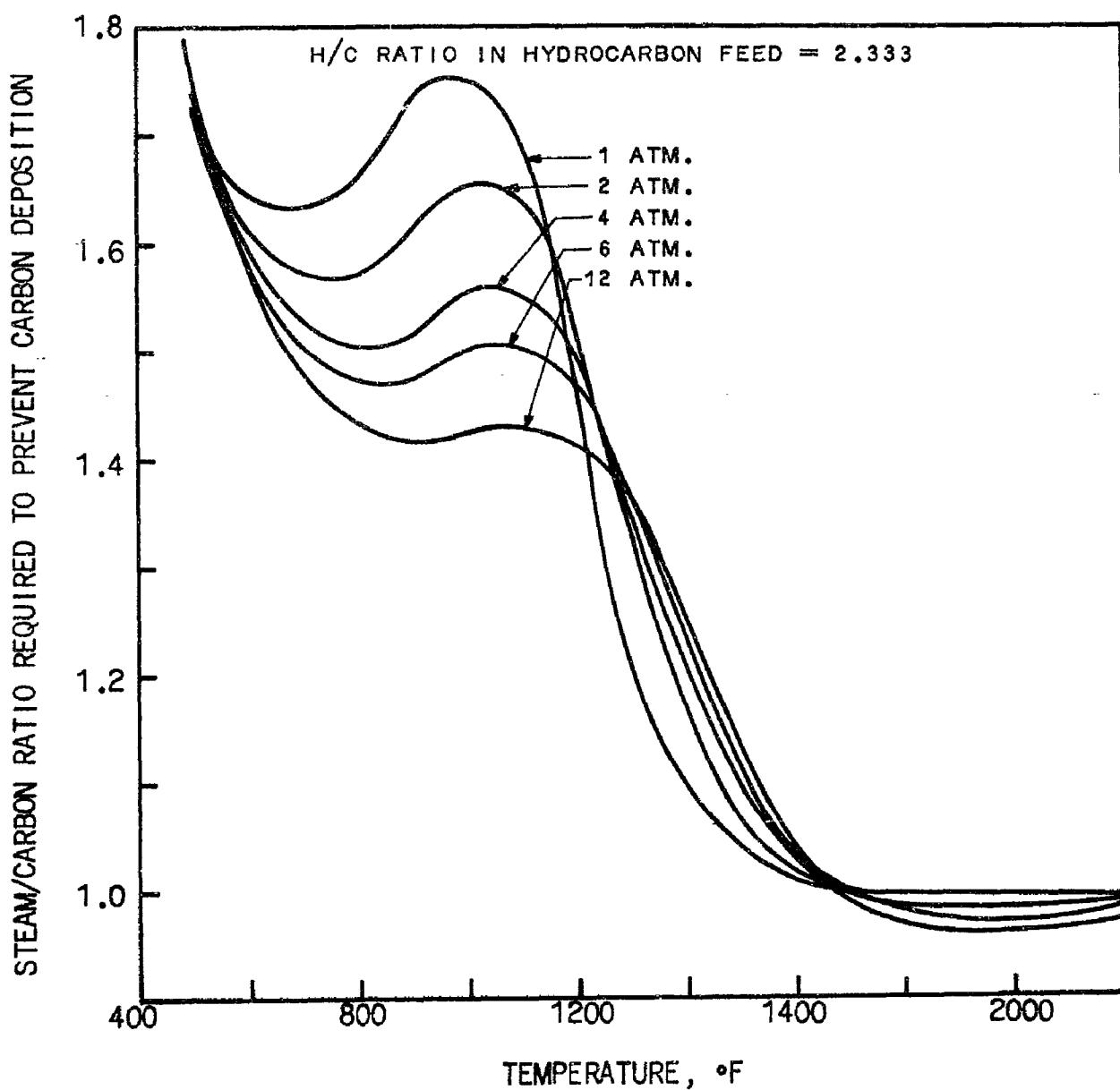
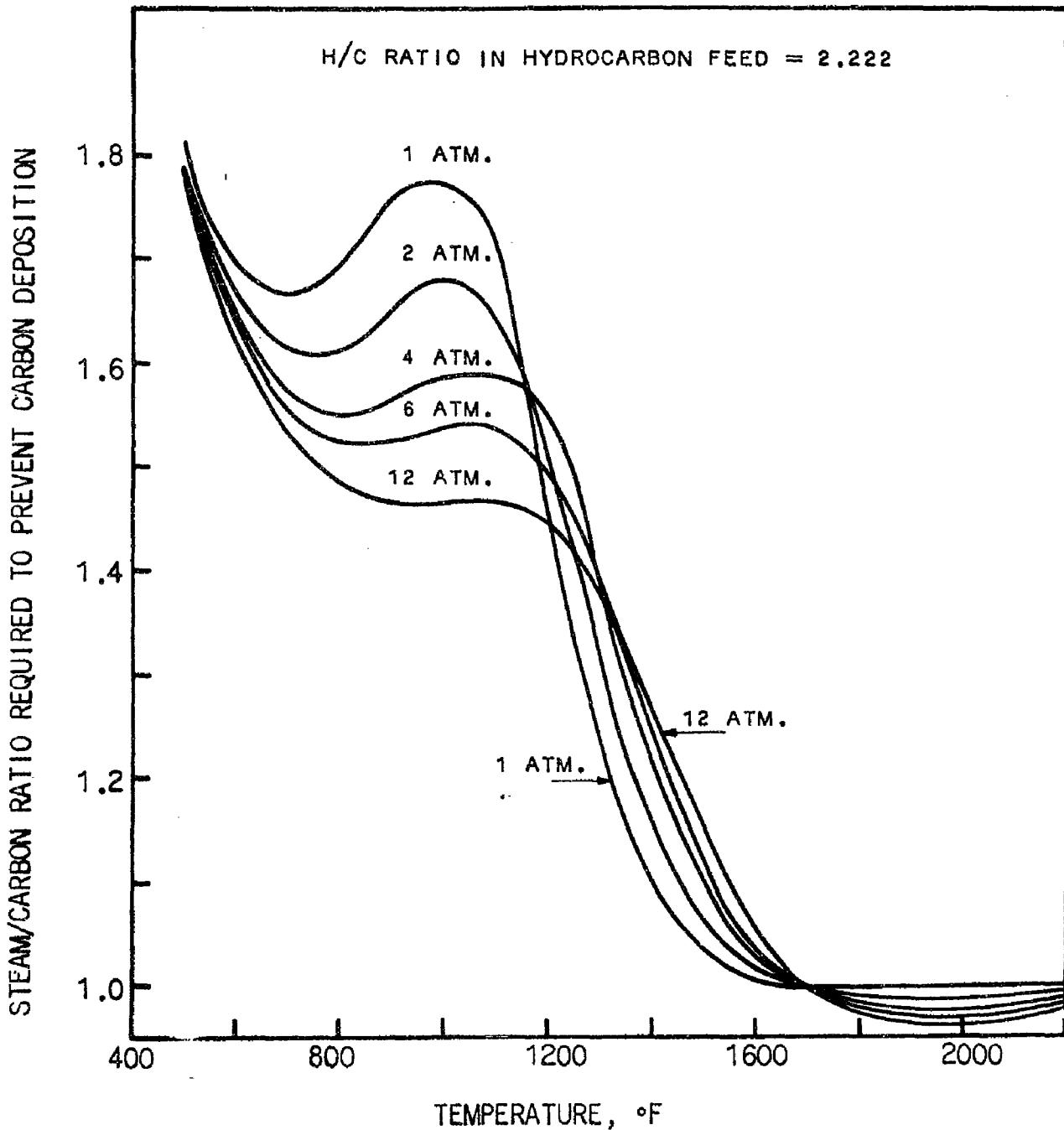


FIGURE G-4

EFFECT OF PRESSURE ON STEAM/CARBON RATIO REQUIRED TO PREVENT CARBON DEPOSITION FROM C_9H_{20} HYDROCARBONS



G-5

11-6-64

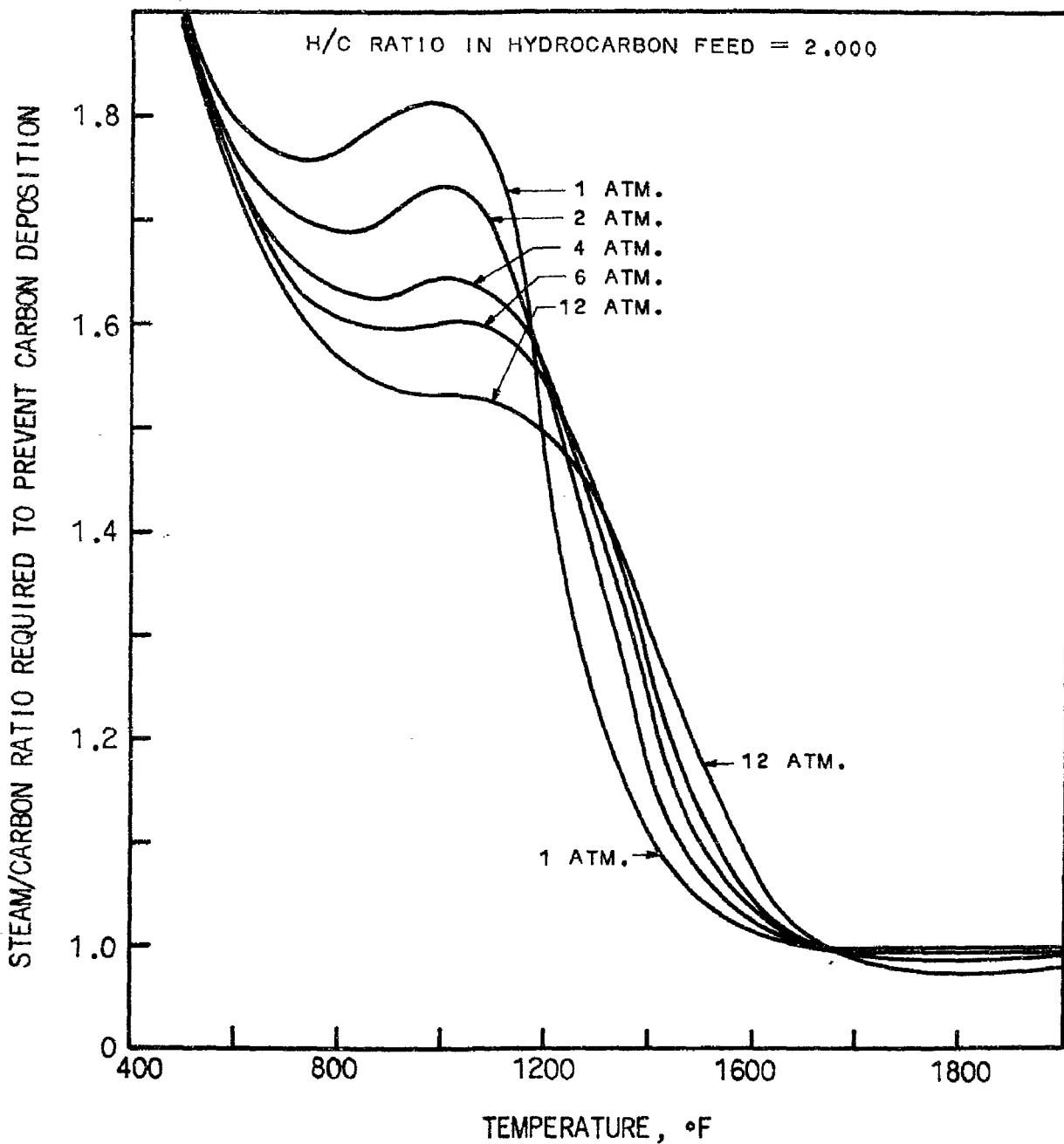
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FIGURE G-5

EFFECT OF PRESSURE ON STEAM/CARBON RATIO REQUIRED TO PREVENT CARBON DEPOSITION FROM $C_{N}H_{2N}$ HYDROCARBONS



G-6

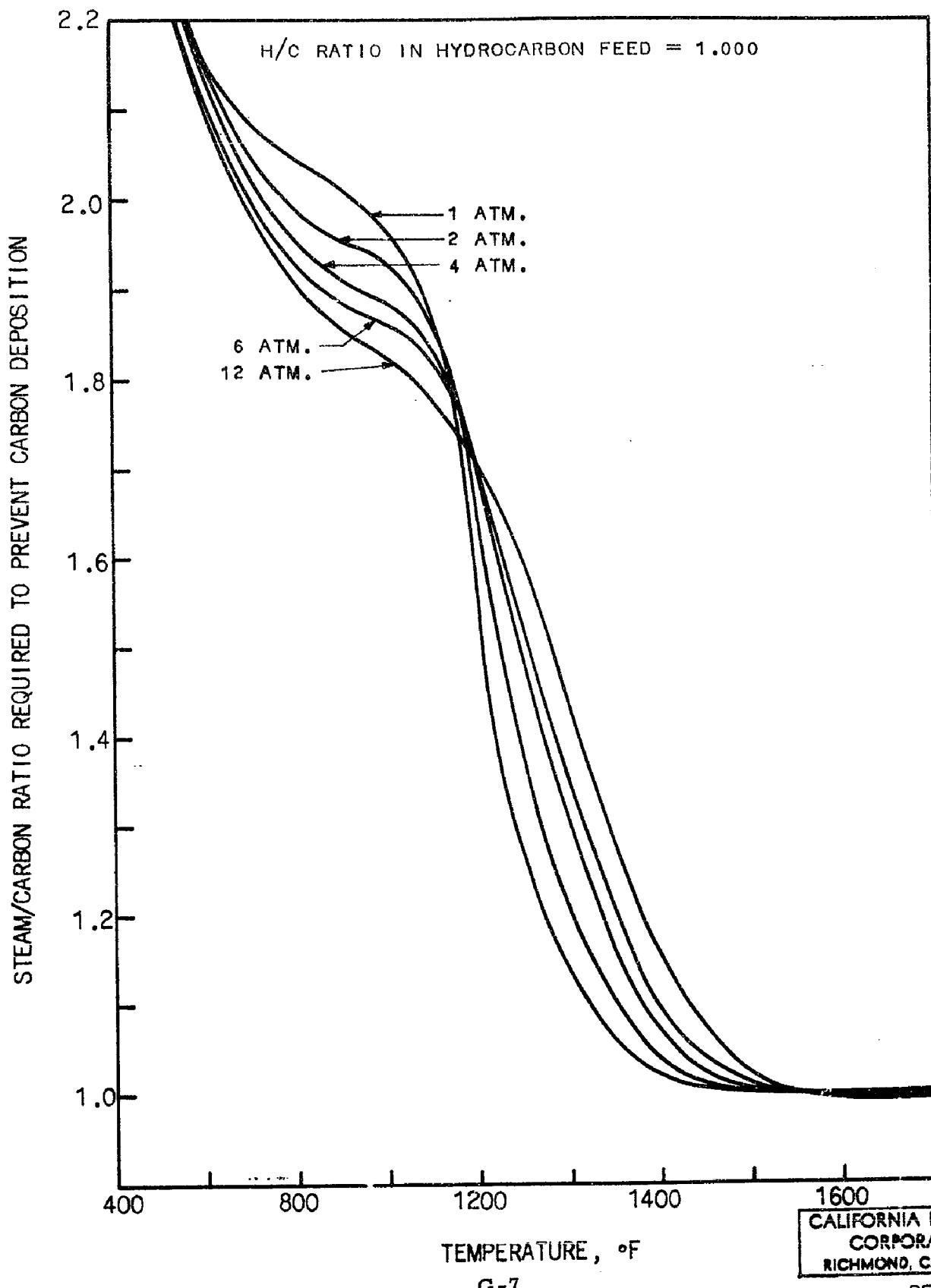
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FIGURE G-6

A-E-6

EFFECT OF PRESSURE ON STEAM CARBON RATIO REQUIRED TO
PREVENT CARBON DEPOSITION FROM $C_{N H_N}$ HYDROCARBONS



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G-7

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